COOPERATIVE
IMPACT ASSESSMENT
REPORT

THE BIOLOGIC AND ECONOMIC ASSESSMENT OF TRICHLOREFON

United States
Department of
Agriculture

In Cooperation
with

State Agricultural
Experiment Stations

Cooperative Extension
Service
Other State Agencies

Technical Bulletin
Number XXXL

THE BIOLOGIC AND ECONOMIC ASSESSMENT OF

TRICHLORFON

A report of the Trichlorfon Assessment Team to the proposed Special Review of Trichlorfon.

Submitted to the Environmental Protection Protection Agency on July 20, 1989.

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PREFACE

This report is a joint project of the U.S. Department of Agriculture, and the State Land-Grant Universities. This report is prepared by a team of scientists from these organizations to provide sound current scientific information on the benefits of, and exposure to, trichlorfon.

The report is a scientific preparation to be used in connection with other data as a portion of a total body of knowledge in order to determine whether the need for a formal Special Review of TRICHLORFON is warranted or whether alternative terms may be arranged for reregistration, or yet again, whether an unmodified reregistration may be justified for this insecticide.

Sincere appreciation is extended to the Assessment Team members and to those others who generously provided information used in the development of this report.

PREFACE

This report is a joint project of the U.S. Department of Agriculture, and the State Land-Grant Universities. This report is prepared by a team of scientists from these organizations to provide sound current scientific information on the benefits of, and exposure to, trichlorfon.

The report is a scientific assessment to be used in conjunction with other data as a portion of a total body of knowledge in order to determine whether the need for a formal Special Review of TRICHLORFON is warranted or whether alternative terms may be arranged for registration, or yet again, whether an unmodified registration may be justified for this insecticide.

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Executive Summary

Trichlorfon is an organophosphorus insecticide with moderate/low mammalian oral toxicity and similarly moderate/low dermal, inhalation and eye contact toxicity. With the exception of specific aquatic immature insects trichlorfon has limited adverse effects on the environment, natural habitats, or to beneficial organisms of value to man.

EPA has not currently instituted a Special Review of Trichlorfon, and the best available information indicates that inadequate data exists to conclude that a "trigger" exists to initiate a regulatory review. This assessment was undertaken in response to a cooperative exchange of information between USDA/EPA, primarily as a concern that a primary degradative product of trichlorfon is dichlorvos. Dichlorvos itself is the object of a special review, and the technical documents prepared by EPA for both chemicals request data from studies defining almost every aspect of health and environmental concerns.

The responses to inquiries extended to state crop specialists requesting data describing trichlorfon were extremely limited because of three predominant reasons. These are:

1. Preferred alternatives are generally used to control pests on commodities for which trichlorfon is registered.
2. Because the two major suppliers of trichlorfon have not agreed to commit efforts and resources toward providing data gap information to EPA, crop specialists anticipate that the reregistration process

will result in eventual suspension of the product's registration under §3(c)(2)(B). Suspension would not result for health reason, but for failure to fill data gaps.

3. Lack of aggressive marketing of the product is evident in cropping areas. Several crops have been deleted from the product labels, and crop specialists observed that the product was not readily available for use in local areas of need.

As a consequence of the observations made above, the Benefits Assessment Team was required to work without benefit of a broad base of information that would normally be obtained from state sources. The study thus became inductive with reliance upon the experience and general knowledge of the team members who are specialists on those pesticide use sites that are yet retained on the registered labels.

A capsule summary of the deliberations of the assessment team supported by available use and benefit data is provided below.

Blueberries as a national crop will be essentially unaffected by the availability of trichlorfon. The limited amount of the insecticide applied to table beets would similarly have no effect on their production, and the use of trichlorfon on tomatoes is not essential to the production of the crop.

Limited amounts of trichlorfon are applied to sweet corn and the economic stability of the crop would not be affected by the availability of the insecticide.

Trichlorfon does have limited value in the production of alfalfa seed and there is considerable economic benefit from treatment with it or one of three chemical alternatives. Montana uses the greater proportion of trichlorfon, and while the three alternatives provide economic benefits, one is under Special Review and the other two are being considered as potential candidates for special reviews. Trichlorfon does exhibit resistance problems in the alfalfa seed production areas outside Montana.

Trichlorfon is used on less than one percent of the total 5.4 million acres of field corn treated to control the armyworm/cutworm complex. An estimated annual average of 6,595 pounds of active ingredients was used in six states in 1985-1987. Use of chemical and non-chemical alternatives to trichlorfon would not affect production cost, efficacy, or yield.

Turfgrass derives marked benefit from the application of trichlorfon and the chemical is popularly used in a limited number of states. Minimal hazard to humans and the compatible environmental effects of trichlorfon make it one of the more desirable late season white grub treatments.

The primary uses of trichlorfon (Neguvon) in livestock are controlling cattle grubs and lice. Alternative control of grubs or lice is provided by Tiguvon (fenthion), Warbex (famphur), Ivomec (ivermectrin, a fungus toxiod), and Co-ral (coumaphos). Alternative control for lice only is

provided by Atroban (permethrin), Ectrin (fervalerate), Ectiban (permethrin), malathion, methoxychlor, Rabon (tetrachlorvinphos) and Ravap (a mixture of tetrachlorvinphos plus dichlorvos). Use of alternatives would have minor effects on efficacy and cost of control.

A 1986-1988 annual average of 175,233 gallons of trichlorfon was used for cattle grub and lice control. The number of cattle treated by this amount varies by the size of the animals, ranging from 22.4 million if only 200-pound animals are treated; to 4.4 million if only 1000-pound animals are treated. Alternative insecticides to trichlorfon, for cattle grub and lice control, are applied as injections, pour-ons, food additives, sprays, and dips. The most important alternatives are applied as either injections (Ivomec) or as pour-ons (Warbex, Tiguvon, Spotton). Trichlorfon and other spray-applied insecticides are used less than injection and pour-on insecticides due to the relative inconvenience of spray-applied insecticides and the need for costly application equipment.

The Benefits Assessment team has generally concluded that the continued use of this insecticide is in geographically isolated regions where alternative chemicals are normally available that can provide economic benefits. The rationale that supports the selection of any of the alternatives is not clear, and the answer may lie in marketing strategy.

The greatest benefits of trichlorfon to agriculture are its chemical diversity in the rapidly decreasing arsenal of pesticides, and its desirability with respect to minimal human and environmental hazards.

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[illegible] lo), mulathion, meta[illegible], [illegible]

[illegible] re of [illegible]

[illegible] have minor effects on efficacy [illegible]

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Ground animals are treated; [illegible]

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control, are applied as [illegible]

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and the answer [illegible] in [illegible]

[illegible] of substitution [illegible]

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Introduction

On June 30, 1984 EPA published the Guidance for the Reregistration of Pesticide Products Containing Trichlorfon as the Active Ingredient (commonly referred to as the Registration Standards). The "Standards" were prepared for reference to the manufacturing use products destined for incorporation in registered formulations containing trichlorfon as the sole active ingredient. Chemical, environmental, toxicology, tolerances for registered food and feed sites, and data/labeling requirements were addressed in that publication.

During an earlier review, trichlorfon had been introduced into the RPAR process (Fed. Reg. Vol. 43, No. 77, April 20, 1978) because data suggested that the chemical might be oncogenic, teratogenic, fetotoxic and mutagenic. EPA concluded that the data available at that time did not support an RPAR. It was also determined that additional studies of oncogenicity, chronic feeding, teratogenicity, mutagenicity, inhalation, dermal toxicity, and metabolism are required. EPA further stated that a decision as to whether the trigger (RPAR) criteria listed in 40 CFR § 162.11a have been met or exceeded would be made subsquent to submission of data from the additional studies.

The data-gap studies that had been requested by EPA had not been received by the date of publication of the "Registration Standards", and EPA was led to conclude that the "Trigger" criteria had not been met or exceeded on the basis of available evidence. That segment of the referenced document is duplicated below for full comprehension of the current status of trichlorfon in the regulatory scenario.

Regulatory Position

Based on a review and evaluation of data and other relevant information on trichlorfon, EPA has made the following determinations:

"1. The data that have been reviewed do not show that the criteria listed in 40 CFR §162.11 (a) have been met or exceeded for the uses of trichlorfon listed in this Guidance Document. However, because of gaps in the data base, the Agency cannot complete a full assessment of trichlorfon.

2. The agency is unable to complete a tolerance reassessment because of extensive residue chemistry and toxicology data gaps. Future requests for tolerances will not be considered or approved until all the chronic toxicology data requirements have been satisfied.

3. No federal or state reentry intervals have been established for trichlorfon. However, based on available environmental fate

deterging studies that had been required by EPA [illegible] received the date of publication of the Registration Standard. [illegible] to conclude that the "trigger" [illegible] has not been [illegible] basis of [illegible] evidence. That [illegible] allocated below for full [illegible] action in the regulatory scenario.

[illegible] Position

[illegible] review and evaluation of data and other information [illegible] action, EPA has made the following determinations:

The data that have been reviewed [illegible] listed in 40 CFR §158.[illegible] (a) [illegible] been [illegible] of trichlorfon listed in this Guidance Document. [illegible] of gaps in the data base, the Agency cannot complete a full assessment of trichlorfon.

2. The Agency is unable to complete a tolerance reassessment because [illegible] residue chemistry and toxicology data gaps. [illegible] requests for tolerances will not be considered [illegible] until [illegible] chronic toxicology data requirements have been satisfied.

[illegible] intervals have been established for [illegible] however, [illegible] environmental fate

and toxicology data, the Agency is requiring an interim reentry interval of 24 hours. This reentry interval will be re-evaluated when the data requirements in Tables A and B have been satisfied.

4. Manufacturing-use pesticide products containing trichlorfon as the sole active pesticide ingredient may be registered for sale, distribution, reformulation, and use, subject to the terms and conditions specified in this Guidance Document.

5. Registrants must provide or agree to develop additional data, as specified in the data tables, in order to maintain existing registrations or to obtain new registrations for substantially similar MPs.

6. There are unique label precautions that must be included on the labeling for trichlorfon products. These precautions are cited later in the document."

Additional considerations that were not detailed in the preceding segment of the regulatory position are that trichlorfon rapidly breaks down in soil, and that its predominant preliminary degradation product is dichlorvos (DDVP). Dichlorvos as an active ingredient was itself the object of a Special Review because studies had suggested that it was potentially carcinogenic, neurotoxic, teratogenic, and mutagenic.

In 1982 (Decision Document on Dichlorvos, U.S., EPA Washington, D.C. September 30, 1982) EPA concluded that the available data did not support a regulatory action against dichlorvos and it was returned to the registration process. The concurrent concerns that existed for trichlorfon as a degradative source of dichlorvos were also set aside at the time of the decision. At that time, EPA asked that studies of mutagenicity and carcinogenicity be completed for dichlorvos in order to provide essential data to allow the completion of a risk assessment.

Subsequently, a Data Call-In Notice requesting submission of data derived from requested studies was issued on March 23, 1983. Those data together with results from tests performed by the National Cancer Institute defining the potential hazards for carcinogenicity will be used by EPA in the final regulatory decision on dichlorvos. As previously explained, the hazards of dichlorvos are considered common to trichlorfon with respect to toxicology and health effects. Thus the influence of any regulatory decision on dichlorvos will naturally impact the status of trichlorfon.

More recently in the chronology of the regulatory process, the FIFRA Scientific Advisory Panel held an open meeting in Arlington, VA on September 28, 1989 and concluded that a reclassification of the oncogenic potential of dichlorvos was appropriate in the light of more recent additional studies. Hence the oncogenic hazard of dichlorvos was downgraded to Class C which suggests that any regulatory action against trichlorfon might also be less severe.

GENERAL INFORMATION

Trichlorfon is a general use organophosphate contact-action insecticide. It has been commonly sold in the United States and internationally under a number of trade names. These are reproduced in the following list.

Anthon	Leviasom
Bay 13/59	Neguvon
Bovinox	Proxol
Briten	Trichlorfon
Cerkufon	Trichlorophene
Ciclosom	Trichlorophon
Crinex	Trinex
Danex	Tugon
Dipterex	Tuzon
Dylox	Vermicide Bayer 2349
Equino-Aid	

EPA's "Registration Standards" reference the existence of thirteen federally registered manufacturing use products that contain trichlorfon as the single active ingredient, and one combination active ingredients product containing trichlorfon. A total of 118 end use products are also referenced in that document for pest control on vegetables, fruit, field crops, livestock, ornamentals and forestry plantings, agricultural premises, domestic dwellings, and for the control of parasites of fish in designated aquatic environments. Some of these site uses have more recently been removed from the labels by the registrants, partly due to generally diminished uses, interest, and revenues, and in part due to the anticipated expenses that would attend the data-gap studies required for reregistration.

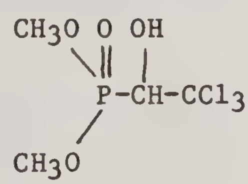
Chemical Identification, Safety,

and Health Information

In the interests of clarity, the descriptive and technical features of trichlorfon are listed below as they are presented in the Material Safety Data Sheet. (Mobay Chemical Corporation MSDA issued August 15, 1985.)

I. PRODUCT IDENTIFICATION

PRODUCT NAME..............:	Trichlorfon Technical
PRODUCT CODE NUMBER ......:	Formula No. 605161
CHEMICAL FAMILY...........:	Organophosphorus Pesticide
CHEMICAL NAME.............:	Dimethyl (2,2,2-trichloro-1-hydroxyethyl) phosphonate
SYNONYMS..................:	Trichlorfon, DIPTEREX, NEGUVON, DYLOX
CAS NUMBER................:	52-68-6
T.S.C.A. STATUS...........:	Registered under FIFRA
STRUCTURE.................:	



II. HAZARDOUS INGREDIENTS

COMPONENTS:	%:	CURRENT TLV:
Trichlorfon	98	NE

III. PHYSICAL DATA

APPEARANCE................:	Solid
COLOR.....................:	White
ODOR......................:	Weak chlorine
MOLECULAR WEIGHT..........:	257.6
MELT POINT................:	81-82°C

III. PHYSICAL DATA (continued)

BOILING POINT.............:	100°C @ 0.1 mm Hg
VAPOR PRESSURE............:	NE
VAPOR DENSITY (AIR=1).....:	NE
SPECIFIC GRAVITY..........:	NA
BULK DENSITY..............:	60-65#/ft.^{3}
SOLUBILITY IN WATER.......:	9% @ 20°C
% VOLATILE BY VOLUME......:	approx. 2.0 mg/m^3 @ 40°C

IV. FIRE & EXPLOSION DATA

FLASH POINT °F(°C)........:	NA
FLAMMABLE LIMITS-	
Lel.......................:	NA
Uel.......................:	NA
EXTINGUISHING MEDIA.......:	Water spray, DCP, Foam, CO_2

SPECIAL FIRE FIGHTING PROCEDURES/UNUSUAL FIRE OR EXPLOSION HAZARDS:
Keep out of smoke, cool exposed containers with water spray. Fight fire from upwind position. Use self-contained breathing equipment. Contain runoff by diking to prevent entry into sewers or waterways. Equipment or materials involved in pesticide fires may become contaminated.

V. HEALTH EFFECTS DATA

ANIMAL TOXICITY - ORAL, LD50 (INGESTION)...........:	Male rat 184 mg/kg Female rat 136 mg/kg
DERMAL, LD50 (SKIN CONTACT)..........:	Male rabbit greater than 2,100 mg/kg
INHALATION, LC50..........:	Male rat greater than 10 mg/l/hr
FISH, LC50................:	Bluegill 0.26 ppm (96 hr.) Rainbow Trout 1.4 ppm (96 hr.)
EYE EFFECTS...............:	Causes moderate irritation
SKIN EFFECTS..............:	Not irritating. Technical Trichlorfon is a moderate contact allergen in guinea pigs.

HUMAN EFFECTS
OF OVEREXPOSURE.........: Trichlorfon is a toxic chemical, which like other organophosphate compounds inhibits the enzyme cholinesterase. Uncontrolled exposure to Trichlorfon can produce symptoms such as nausea, sweating, a sense of tightness in the chest and contricted pupils. Increasing exposure can produce more serious symptoms such as stomach pains, vomiting and diarrhea, while grossly excessive exposure can produce symptoms of life threatening effects, such a muscular tremors, uncontrolled mucous secretion, convulsions and coma.

EXPOSURE GUIDELINES.......: NE

IV. EMERGENCY & FIRST AID PROCEDURES

IN CASE OF POISIONING.....: Call physician or poison control center

EYE CONTACT...............: Flush with water for at least 15 minutes. Get medical attention.

SKIN CONTACT..............: Wash skin immediately with soap and water.

INHALATION................: Remove to fresh air. If not breathing, give artificial respiration, preferably mouth to mouth. Get medical attention.

INGESTION.................: Administer water freely and induce vomiting by giving one dose (1/2 oz. or 15 ml) of syrup of ipecac. If vomiting does not occur within 10-20 minutes, administer second dose. If syrup of ipecac is not available, induce vomiting by sticking finger down throat. Repeat until vomit fluid is clear. Never give anything by mouth to an unconscious person. Get medical attention immediately.

TO PHYSICIAN..............: ANTIDOTE - Administer atropine sulfate in large therapeutic doses. Repeat as necessary to the point of tolerance. 2-PAM is also antidotal and may be administered in conjunction with atropine.

Compound inhibits cholinesterase resulting in stimulation of the central nervous system, the parasympathetic nervous system and the somatic motor nerves. Do not give morphine. Watch for pulmonary edema which may develop in serious cases of poisoning even after 12 hours. At first sign of pulmonary edema, the patient should be placed in an oxygen tent and treated symptomatically.

In case of poisoning, it is also requested that Mobay Chemical, Agricultural Chemicals Division, Kansas City, Missouri, be notified. Telephone: 816-242-2000; nights or week-ends: 816-242-2582.

VII. EMPLOYEE PROTECTION RECOMMENDATIONS

EYE PROTECTION............:	Goggles
SKIN PROTECTION...........:	Latex or neoprene gloves, rubber boots & apron
RESPIRATORY PROTECTION....:	Wear a respirator jointly approved by the Mining Enforcement & Safety Administration (formerly U.S. Bureau of Mines) and by the National Institute for Occupational Safety & Health under the provision of 30 CFT Part II. In Canada, obtain this information from your dealer.
VENTILATION...............:	Minimize exposures through use of general and local exhaust ventilation.
OTHER.....................:	Launder clothing daily after use. Wash thoroughly after handling.

VIII. REACTIVITY DATA

STABILITY.................:	Unstable
POLYMERIZATION............:	Will not occur.
CONDITIONS TO AVOID.......:	Temperatures above 100°F.
INCOMPATIBILITY (MATERIALS TO AVOID)....:	Alkali, strong oxidizing agents.
HAZARDOUS DECOMPOSITION PRODUCTS................:	CO, P_2O_5, DDVP, HCl

IX. SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Avoid breathing dusts and skin contact. Carefully sweep up spilled material and place in covered container. Scrub contaiminated area with alcohol and caustic solution. Repeat and rinse with water.

WASTE DISPOSAL METHOD: Bury material in EPA-approved landfill or burn in an incinerator approved for pesticide destruction.

X. SPECIAL PRECAUTIONS & STORAGE DATA

STORAGE TEMPERATURE (MIN./MAX.).............:	0°F/30-day average not to exceed 100°F
SPECIAL SENSITIVITY (HEAT, LIGHT, MOISTURE) :	Heat, moisture
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING :	Store in a cool dry area. Store the liquid formulations away from excessive heat and open flame. Store in an area designated specifically for pesticides. Do not store near any material intended for use or consumption by humans or animals.

XI. SHIPPING DATA

D.O.T. SHIPPING NAME......:	NA
TECHNICAL SHIPPING NAME...:	Trichlorfon
D.O.T. HAZARD CLASSIFICATION..........:	NA
UN/NA NO..................:	NA
REPORTABLE QUANTITY.......:	NA
D.O.T. LABELS REQUIRED....:	NA
D.O.T. PLACARDS...........:	NA
FRT. CLASS BULK...........:	Insecticide, Agricultural, O/T Liquid
FRT. CLASS PKG............:	Insecticide, Agricultural, O/T Liquid

XII. DOCUMENTATION

REASON FOR ISSUE..........:	Revise to new format
APPROVED BY...............:	William J. Brinkman
TITLE.....................:	Industrial Hygiene Manager
DATE APPROVED.............:	August 15, 1985

Ecological Characteristics

Trichlorfon is environmentally safe, has less impact on beneficial organisms, and is less phytotoxic to crop plants (See p.48, Simko and Brindley, Unpublished data). These generalizations are generally true, and while research interests now center upon more recently developed pesticides, earlier studies that have been documented firmly support those observations. A generalization of 20 separate but relevant studies (Croft and Brown, 1975) determined that trichlorfon was only moderately toxic to predacious lady beetles. Those same researchers found trichlorfon to be least toxic when evaluated against the adults of 17 species of hymenopterous parasites and one Tachinid. More specific observations of the minimal effects of trichlorfon on beneficial organisms were made (Reynolds, 1971) when the insecticide was sprayed on cotton for the control of lygus bugs without causing a secondary population upsurge of cotton leaf perforator or other pest species. This would have understandably occurred if beneficial species been adversely affected.

Similarly, (Edwards et al., 1968) centipedes that are useful as beneficial predators were to some extent reduced in numbers by trichlorfon, but certainly not so seriously as observed with other insecticides. Other observations (Edwards et al., 1969) had already established that trichlorfon when applied to the soil had little effect on earthworms. It did not cause heavy initial kills nor have any lasting effect on earthworm populations.

Trichlorfon is in fact one of the most forgiving insecticides to the general environment. Under normal circumstances its residues are short-lived and non-persistent. It is an aliphatic phosphonate that is vulnerable to microorganisms in the soil. Degradation studies (Zayed et al., 1965) demonstrated that it is easily dealkylated by *Aspergillus*, *Penicillium*, or *Fusarium* into monomethyl trichlorohydroxyethyl phosphonate and a metabolite speculated to the trichlorohydroxyethyl phosphonic acid. This occurs commonly in soil residues.

Trichlorfon is also regarded as one of the safer insecticides that might come in contact with aquatic environments. It was once viewed as a possible candidate for gypsy moth control, and as such was evaluated for its impact upon aquatic species. One earlier study (Carlson, 1966) was designed to show that trichlorfon was a suitable candidate to control emerging aquatic species. LC_{50} data of 24 hr exposure demonstrated that 910 ppb was needed to suppress *Hexagenia* mayflies. *Hydropsyche* species were more susceptible with an LC_{50} of 17 ppb. The study showed that while trichlorfon was more effective than malathion in the control of emerging aquatic species, it was 100X less toxic to bluegills. In fact, trichlorfon had little effect on aquatic species as a whole when applied at the rate of 1.0 lb a.i./A. In yet another study (Sanders & Cope, 1968) trichlorfon was found to be moderately toxic to nymphs of the stonefly *Pteronarcys californica*. It was the least toxic of ten pesticides when assayed for mortality of *Pteronarcella badia* and *Classenia sabulosa* when exposed test concentrations for 24 hrs and at 96 hrs.

Pimentel (1971) found that out of 39 pesticides, trichlorfon ranked 27 (1 being most toxic) against rainbow trout.

Other comparisons:	22/23 fathead minnow
	13/23 bluegills
	18/23 goldfish
	12/23 guppies

General studies performed by Finger and Werner (1970) determined that trichlorfon was 1000 times less hazardous to stream fish than DDT. Trichlorfon applied at 1.0 lb/A for gypsy moth control in New York State had no effect on fish; brook trout could tolerate up to 1.0 ppm and that residue was virtually all lost in 4 days. Trichlorfon is one of the decidedly unique insecticides with regard to its safety in the ecological food chain. In a test of 16 pesticides and an organic solvent evaluated on five species of marine algae believed important as food for oysters and clams, trichlorfon and TEPP were the two least toxic and were tolerated in concentrations of several parts per million.

General Oversight

EPA identifies many data gaps in the Trichlorfon Guidance Document. Filling the numerous gaps would be costly. Although some pertinent data may be generated from the dichlorvos investigations, all trichlorfon gaps may not be filled.

SYNOPSES OF THE CROPS, PESTS AND USE PARAMETERS FOR TRICHLORFON

The producers of trichlorfon have publicly announced their reduction of site uses for trichlorfon formulations. The following synopses represent the team's best understanding of current formulation labels.

Fruit and Nut Crop Uses

BLUEBERRIES

<u>Spanworm</u> - Apply 0.8 lb a.i./A.

NOTES AND LIMITATIONS: Apply in sufficient water for complete coverage but not less than 1 gal/A. Make a pre bloom application as soon as insects appear. A second application may be made during bloom but not less than 7 days after first application. Do not apply after bloom.

PHI: N/A

TOLERANCE: 0.1 ppm

Vegetable Crop Uses

TABLE BEETS

<u>Armyworms</u>

<u>Bug (lygus)</u> - Apply 1.0 -1.5 lb a.i./A.

Alfalfa webworm

Beet webworm

Dipterous leafminers

Salt-marsh caterpillar - Apply 1.0 lb a.i./A.

NOTES AND LIMITATIONS: Apply in sufficient water for coverage, but not less than 1 gallon per acre. Make a pre bloom application as soon as insects appear. A second application may be made during bloom but not less than seven days after first application. Do not eat tops.

PHI: 28 days

TOLERANCE: 0.1 (N) ppm

PUMPKIN

Variegated cutworm - Apply 0.5-1.0 lb a.i./A.

Squash bug - Apply 1.0 lb a.i./A.

NOTES AND LIMITATIONS: Apply in sufficient water for complete coverage but not less than 1 gal/A. Do not apply more than 3 times per season.

PHI: 3 days.

TOLERANCE: 0.1 (N) ppm

TOMATOES

Serpentine leafminers

Tomato hornworms

Dipterous leaf miners - Apply 1.0 lb a.i./A.

NOTES AND LIMITATIONS: Apply in sufficient water for complete coverage but not less than 1 gal/A. Repeat as necessary.

PHI: 21 days

TOLERANCE: 0.1 (N) ppm

Grass and Legume Crop Uses

ALFALFA, CLOVER

(Including mixed stands with grasses)

Alfalfa caterpillar - Apply 0.375-0.50 lb a.i./A.

Alfalfa webworm - Apply 0.25-1.0 lb a.i./A.

Western yellow-striped armyworm - Apply 0.50 lb a.i./A.

Beet armyworm

Leafhoppers

Variegated cutworm - Apply 0.50-1.0 lb a.i./A.

Armyworm

Alfalfa plant bug

Lygus bugs

Stink bugs

Tarnished plant bugs - Apply 1.0 lb a.i./A

NOTES AND LIMITATIONS: Apply in sufficient water for complete coverage but not less than 1 gal/A. Three applications may be made per cutting.

PHI: 0 days

TOLERANCE: Alfalfa 60 ppm; alfalfa hay 90 ppm

BIRDSFOOT TREFOIL (Except California)

Armyworms

Lygus bugs

Stink bugs

Variegated cutworm - Apply 1.0-1.5 lb a.i./A

NOTES AND LIMITATIONS: Apply in sufficient water for complete coverage but not less than 1 gal/A. Repeat as necessary. Chaff and hay may be used for feed or forage; however, do not cut green crop for these purposes.

PHI: 7 days.

TOLERANCE: 90 ppm

Field Crop Uses

CORN - FIELD, SWEET, POPCORN

Armyworms

Cutworms - Apply 0.5-1.0 lb a.i./A.

NOTES AND LIMITATIONS: Apply in sufficient water for complete coverage but not less than 1 gal/A. Three applications may be applied per season. For early application spray lower portions of plants and to soil at the base of plants. Later applications may be made as full coverage sprays.

PHI: 0 days.

TOLERANCE: Forage and fodder 30 ppm; Grain 0.1 (N) ppm

COTTON

Cotton fleahopper - Apply 0.25-1.0 lb a.i./A.

Cotton leafworm

Darkling ground beetle

Western yellow-striped armyworm - Apply 0.5-1.0 lb a.i./A.

Beet armyworm

Southern garden leafhopper - Apply 1.0 lb a.i./A.

Black fleahopper complex

Cotton leaf perforator

Leaf roller

Lygus bugs

Stink bugs - Apply 1.0 -1.5 lb a.i./A.

Salt-marsh caterpillar - Apply 1.5 lb a.i./A.

NOTES AND LIMITATIONS: Apply in sufficient water for complete coverage but not less than 1 gal/A. Application may occasionally cause marginal leaf burn.

PHI: 7 days for picking.

14 days for pasturing animals.

TOLERANCE: Cottonseed 0.1 (N) ppm

TOBACCO

Budworm

Hornworm - Apply 1.0 lb a.i./A.

Green /June beetle larvae - Apply 0.50 lb a.i./100 sq. yards of uprooted areas of plant beds.

NOTES AND LIMITATIONS (Budworm and Hornworm): Apply in sufficient water to complete coverage but not less than 1 gal/A. For budworm control make application directly into bud. Repeat as necessary.

PHI: 3 days.

TOLERANCE: No Tolerance

ALFALFA, CLOVER SEED

Armyworms

Lygus bugs

Stink bugs

Variegated cutworm - Apply 1.0-1.5 lb a.i./A.

SOYBEANS SEED

Armyworms

Dipterous leaf miners

Lygus bugs

Variegated cutworms - Apply 1.0-1.5 lb a.i./A.

NOTES AND LIMITATIONS: Apply in sufficient water for complete coverage but not less than 1 gal/A. Repeat as necessary. Chaff from alfalfa and clover seed crop may be used for feed or forage; however, do not cut green crop for these purposes. Do not pasture or use treated soybeans for feed, food, forage, or oil.

PHI: 7 days.

TOLERANCE: Alfalfa 60 ppm; Alfalfa hay 90 ppm; Soybeans - no tolerance

Ornamentals

LAWNS, TURF

Sod webworm - Apply 0.125 lb a.i./A.

White grubs - Apply 0.1875 lb a.i./A.

NOTES AND LIMITATIONS: Apply uniformly over 1,000 sq. ft. of area with any suitable spreader that can be accurately calibrated. For best results, mow and rake dead grass from damaged spots before applying. After application, water the lawn using 15-30 gal per 1000 sq. ft. Do not water again within three days. Repeat applications as necessary at 1-3 week intervals.

PHI: N/A

TOLERANCE: N/A

Livestock

CATTLE - BEEF, NON-LACTATING

Cattle grubs

Lice - Apply 0.5 fl. oz. (0.125 oz. a.i.) per 100 lb of animal weight as a single application placed along the backline.

NOTES AND LIMITATIONS: Do not treat animals within 21 days of freshening. If freshening occurs within 21 days of treatment, do not use milk for food for balance of the 21 days. Do not treat animals for 10 days before or after shipping or weaning, or after exposure to contagious or infectious diseases. Do not treat over-heated animals.

Do not treat animals less than 3 months old.

Do not treat animals that are sick, convalescent, or stressed.

PHI: Do not treat cattle within 21 days of slaughter.

TOLERANCE: Cattle fat, meat, MBYP 0.1 (N) ppm

Methodology of the Benefits Assessment Study

Questionnaires were developed during early organizational contacts among the members of the Benefits Assessment Team. Each general crop (fruit, forage, field crops, etc.) was the concern of specific sub-team groups or individuals who supplied the questionnaires to crop specialists at state agricultural colleges. Most unfortunately, and because of the unique considerations specific to trichlorfon, the responses from state crop specialists were extremely limited. As a consequence of the lack of adequated state information, the sub-team members made personal inquiries during professional meetings and from qualified colleagues who helped to provide some of the missing information. The sub-teams then prepared their narratives using the best available information combined with their specialized expertise. The differences in the quality and quantity of regional data reflect the extent to which the sub-teams were able to obtain valid inputs, and those inputs or the lack thereof were a reflection of the perceived need for the chemical.

The completed drafts for each crop section were provided to the Economic Research Service representative of the Assessment Team who concluded that the data was insufficient for statistical quantification. Thus the assessment has remained generally qualitative in its appraisal of trichlorfon with the conclusion that its value to agriculture is certainly variable with regard to specific crops.

SPECIFIC USE ANALYSES

BLUEBERRIES

INTRODUCTION

The blueberry, Vaccinium, is a true berry having small, soft seeds. Three distinct types of blueberries are grown for commercial markets: the lowbush type, the highbush type and the rabbiteye type.

Lowbush blueberries, or wild blueberries, consist of several species, including V. angustifolium, V. lamarckii, V. vacillans and others. The flower and fruits are borne on the previous years growth, the plants spread by rhizomes, growing close to the ground, and are essentially wild. No named cultivars exist, and little attempt is made at propagation, planting, or other common horticultural practices, but plants produce small berries that are harvested for commercial preparation (95% of the berries) and fresh consumption (5% of the berries). Seventy percent of the processed berries are for freezing and 30 percent are for canning. Chief production areas include the colder areas where the plant is protected in winter by snow covering, including Maine, New Hampshire, Michigan, and Massachusetts. Other states reporting limited lowbush blueberry production include New York, Wisconsin, Minnesota, Alaska, and West Virginia. Even though only a portion of the total wild crop is harvested, the value of the harvest in North America is estimated to be over $61,000,000.

Highbush blueberries, or cultivated blueberries, include the northern highbush type, V. coryimbosum, and the southeastern highbush type, V. australe. These plants do not spread by rhizomes as do the lowbush, add terminal growth to the canes each year, and individual bushes may persist for many years becoming

tall and thick. Highbush blueberries produce the large berries commonly offered on the fresh market. Many cultivars have been produced from an intensive, long-term breeding program. The major highbush blueberry production areas include New Jersey, Michigan and North Carolina. Other areas include Washington, Oregon, Massachusetts, New York and Indiana. The annual value of this crop is approximately $110,000,000.

Rabbiteye blueberries are selected hybrids of the very tall-growing blueberry species also known as the southern highbush blueberry, V. ashei, grown in the Southern United States. This shrub grows freely on poor, dry, less acid soils, and prefers a warmer climate. Rabbiteye blueberries are native to North Carolina, South Carolina, Georgia, northwestern Florida, Alabama, Mississippi and Louisiana. The annual value of rabbiteye blueberries is approximately $20,000,000.

TABLE 1. Blueberry acreage in the United States. 1986-1988

State	Acreage	Value
New Jersey	8,500	26,000,000
Michigan	18,000	30,000,000
Maine	50,000*	58,000,000
North Carolina	4,000	8,500,000
Washington	2,000	4,500,000
Massachusetts	400	1,000,000
Indiana	800	1,760,000
Arkansas	1,100	1,650,000
New York	2,000	4,500,000
Florida	1,500	5,000,000
Other**	44,200	50,000,000
Total	132,500	190,910,000

* Maine estimates only 1/2 of lowbush acreage is always in production. The other half is undergoing a burning/pruning year.

** Other states include Pennsylvania, Maryland, New Hampshire, Ohio, Oregon, Wisconsin, Alabama, West Virginia, South Carolina, Mississippi, Delaware, Minnesota, and parts of Kentucky.

CURRENT USE ANALYSIS

Approximately 2000 acres of total blueberry production are treated annually with trichlorfon to reduce damage caused by insects, primarily in the states of Maine, New Jersey and Florida. Other states surveyed reported that trichlorfon is not used or recommended due to availability of many alternatives for the pests in those states.

In Maine and Florida, trichlorfon is used according to the Federal Label for control of spanworm on blueberries at a rate of 0.8 lb AI/acre. In New Jersey, trichlorfon is used with a Section 18 Emergency Exemption label for control of gypsy moth larvae when outbreaks occur. These states reported that the use of trichlorfon occurs during pre-bloom and bloom, and an advantage of this material, when used properly, is that it is safer on bees and other beneficial species present at this crop growth stage as compared with most alternatives.

States reporting no use of trichlorfon on blueberries include North Carolina, Colorado, Arkansas, New York, Massachusetts, Ohio, and Indiana. No responses to the survey were obtained from Michigan, Missouri and Washington, and it is assumed that trichlorfon is not used in these states.

PERFORMANCE EVALUATION AND ALTERNATIVES

Trichlorfon is currently used for control of two pests on blueberries, the gypsy moth and spanworms.

Spanworms have a wide range of preferred wild host plants, but occasionally include blueberries, causing extensive damage. The chain-spotted geometrid, *Cingilia catenaria* Drury, can be a periodic pest in Maine, Massachusetts and Canada, attacking lowbush blueberries. It overwinters in the egg stage on fallen leaves of many plants, hatching in early June and feeding on

the foliage. Mature larvae are voracious feeders and can defoliate entire plants. The pupa is formed on the plant in late August and moths emerge in September. Oviposition of overwintering eggs occurs over a long period of time in the fall.

Gypsy moths have recently become an occasional serious pest of blueberries in several counties of New Jersey, including Ocean, Burlington and Atlantic counties, particularly where oak trees are prominent along field edges. Gypsy moths overwinter in the egg stage, hatching in late April or early May. The young caterpillars are voracious feeders, defoliating many species of trees and shrubs. They mature in early July and pupate on trunks and other nearby objects. Moths emerge in late July, the females mating and depositing eggs that do not hatch until the following spring. Normal blueberry spray schedules have controlled most gypsy moth infestations, but in certain heavily infested areas, larvae blow into fields on wind currents when blueberry plants are flowering and can be a problem because larvae feed in the blossom cluster. A bacterial pesticide (Bacillus thuringiensis) usually is sufficient to prevent significant damage. However, when larvae are very abundant during bloom, trichlorfon may be necessary to adequately protect the crop, and is used according to an Emergency Exemption Label in New Jersey.

Table 2. Location and amount of trichlorfon use in the U.S. on blueberies, 1985-1988*.

State	Pounds a.i.	Acres	Pests
Maine	1200	1,500	spanworms
Florida	120	150	spanworms
New Jersey	270	350	gypsy moth

* Based on surveys returned and Dr. W. Carlson, Assistant Director of Research, Mobay Corporation.

ALTERNATIVE CONTROLS

Spanworms are considered minor pests, needing treatment when outbreaks occur. In many states, they never reach pest proportions, and thus require no control measures. A spray program for control of various other pests, including fruit flies, often suppresses spanworms. A non-chemical alternative control measure for spanworms is burn-pruning vegetative fields of lowbush blueberries, reported by Maine. However, it costs an additional $75.00 per acre over standard mowing costs, and burning reduces soil organic matter which can lead to erosion, soil nutrient reduction and reduced yields. Burning also has a potential negative effect on the air quality. No other alternative chemicals are specifically labeled for control of spanworms on blueberries.

Gypsy moths are an economic pest only in some counties in New Jersey during years of heavy infestation. Other states consider gypsy moths to be a non-economic annual pest. The New Jersey State Department of Agriculture has been actively releasing parasites of the gypsy moth, which are now established in heavily infested areas of New England and are effectively helping reduce this pest. Also, the biological pesticides Thuricide and Dipel generally control this pest, although it costs approximately 2X-3X as much as trichlorfon per acre ($5.40-10.80 versus $3.90, respectively). Further, a biological insecticide is less effective in cooler weather than in warmer weather, and trichlorfon would be significantly more effective in controlling heavy infestations of gypsy moth larvae during a period of cool weather at the flower stage of plant development.

Table 3. Comparative cost of trichlorfon versus other insecticides labeled on blueberries for control of various pests.

Material	Rate range lb a.i./acre	Cost/application/acre
trichlorfon	0.8	3.90
azinphosmethyl	0.5-1.0	5.47-10.94
Bacillus thuringeinsis	0.5-1.0	5.40-10.80
diazinon	0.5	3.00
methomyl	0.45-0.90	7.95-15.90
methoxychlor	1.0	6.97
malathion	1.0	2.28
carbaryl	1.5	5.66
parathion	0.5	1.17
endosulfan	1.5	12.69

For spanworm control, there are no alternatives specifically labeled for such use on blueberries. For gypsy moth control, only the biological insecticides are a labeled alternative. Although some of the other insecticides labeled on blueberries would be helpful in reducing spanworm and gypsy moth infestations, most are harmful to beneficial insects that are present at bloom. Label restrictions on diazinon, carbaryl, methomyl and azinphosmethyl prevent the application of these materials during bloom. Methoxychlor and malathion can be applied only during late evening to avoid bee kill. Parathion is under Special Review and might possibly be cancelled. Biological insecticides are ineffective during heavy infestations and periods of cool weather, and are significantly more expensive.

ECONOMIC IMPACT

Based on responses to the survey on trichlorfon use by the states and blueberry production regions, a minimum economic impact on blueberry production costs or yields would occur through cancellation of trichlorfon. The pests for which trichlorfon is labeled (gypsy moths and spanworms) are considered by most states to be insignificant. The state of Maine reported a possible overall yield reduction of approximately 10% of the annual lowbush blueberry harvests without the availability of trichlorfon due to the effect of an unchecked infestation. New Jersey yield reductions without trichlorfon may be 0% to 20% or higher, depending on gypsy moth infestation levels (which are cyclic) and temperatures at time of treatment with the biological materials. Florida reported that no change in yield or quality of fruit would likely occur.

SUMMARY

Results of the survey suggest that the yield and quality of blueberry production will be unaffected through cancellation of trichlorfon use on blueberries. The pests that trichlorfon is labeled for use against, spanworms and gypsy moths, are not considered to be economic pests by nearly all blueberry-producing states, and only sporadically economic in Maine, Florida and New Jersey. Although no alternatives are specifically labeled for spanworm control on blueberry, other insecticides labeled on blueberries and utilized in a pest management program are generally effective in reducing potential problems caused by spanworms and gypsy moths. Maine reports a possible 10% reduction in blueberry yields without trichlorfon, and New Jersey reports a possible 0-20% reduction could occur during some years and when temperatures during flowering are cool. No other states reported that cancellation of trichlorfon would result in any yield loss.

[illegible] to the survey on [illegible]

[illegible] reports, a minimum economic impact on blueberry production would occur [illegible] cancellation of trichlorfon. [illegible]

[illegible] on is labeled (spray, dust and concentrate) [illegible]

[illegible] insignificant. The state of Maine reported [illegible] overall [illegible] approximately 10% of the annual lowbush blueberry [illegible]

[illegible] availability of trichlorfon due to the effect of [illegible]

[illegible] New Jersey yield reductions without trichlorfon [illegible]

depending on [illegible] infestation levels [illegible]

[illegible] at time of treatment with the [illegible] materials. Florida [illegible]

that no change in yield or quality of fruit would likely occur.

[illegible] of the survey suggest that the yield and quality of blueberry [illegible] will be unaffected through cancellation of [illegible]

The pests that trichlorfon is labeled for [illegible]

[illegible] are not considered to be economic pests by [illegible]

[illegible] are only sporadically economic in Maine. [illegible]

[illegible] no alternatives are specifically labeled for [illegible] blueberry, other insecticides labeled on blueberries [illegible] generally effective in reducing [illegible]

[illegible] and [illegible] moths. Maine reports a possible [illegible]

[illegible] trichlorfon, and New Jersey reports a possible [illegible]

[illegible] temperatures during [illegible]

Table Beets

Table beets are grown commercially for processing in about a half dozen states in the U.S. Wisconsin is one of the leading beet producing states with approximately 4,000 acres. Potential trichlorfon usage was reported from Wisconsin and 3 other states. It is labeled for use on table beets for the control of variegated cutworms, dipterous leafminers, beet armyworms, and lygus bugs.

However, none of the four reporting states listed any acreage of table beets treated with trichlorfon. Insects are not a major limiting factor in table beet production and there are effective alternative chemical controls with a shorter pre-harvest interval than the 28 days stipulated for trichlorfon when used on the table beets.

There is very little or no use on table beet acreage which could be treated with this insecticide for insect control. No use was reported in the survey. See p. 147.

Table 4. Use on trichlorfon on Table Beets in the United States.

State	Harvested Acres	Acres treated with trichlorfon	Alternative insecticides	Percent treated
Wisconsin	3,600	unknown or very little used	Lannate Sevin	unknown unknown
New York	no data	none used	---	---
North Carolina	none used	none used	---	---
Indiana	100	none used	---	---

Tomatoes

Current Use

Tomatoes are grown commercially in more than half the states in the U.S. for either fresh market or for processing. Use surveys were received from fifteen states. Ohio reported production of over 18,000 acres with 86 percent grown for processing. Other reporting states with tomato acreage include Tennessee (4,700), Indiana (9,000), New Jersey (9,000), Arkansas (1,650), and Illinois (1,200). No reports related to trichlorfon were received from Florida with 55,000 acres or California with 243,000 acres. Production figures for Florida and California were obtained from the 1987 United States Department of Agriculture, National Agricultural Statistical Service, Agriculture Statistics Board.

Trichlorfon is labeled for the control of tomato hornworms, dipterous leafminers, and serpentine leafminers. There is a 21 day per-harvest interval restriction for trichlorfon used on tomatoes.

Alternative insecticides that are available for use on tomatoes include fenvalerate, methomyl, carbaryl, endosulfan, and esfenvalerate.

Table 5. Cost Comparison of Trichlorfon and Alternative Insecticides

Insecticide	Amount/Formulation	lb a.i./A	$ Cost/lb
Trichlorfon	1/12 lb/80 S	1.0	5.60
Fenvalerate	5 to 10 02/2.4 EC	0.1 to 0.2	3.90-7.80
Carbaryl	1 qt/4 L	1.0	4.00
Methomyl	1 pt/4 L	0.5	6.00
Endosulfan	2 2/3 pt/3 E	1.0	8.46

Alternative insecticides compare reasonably close in cost to trichlorfon. Methomyl costs somewhat more per treatment and carbaryl costs less. Fenvalerate is a common alternative and is used in a range of 0.1 to 0.2 lb a.i. acre.

Fifteen states reported on the usage of the insecticides on tomatoes. Only two of the 14 states reported any trichlorfon usage. Tennessee reported that 3 percent of the 4,700 acres grown in that state were treated with trichlorfon, and Alabama reported 2 percent of 120 total acres treated. All of the other 13 reporting states indicated none, or very little usage of trichlorfon on tomatoes.

There is very little use on the treated tomato acreage for this insecticide.

Table 6. Use of Trichlorfon on Tomatoes in the United States.

State	Harvested Acres	Acres treated with trichlorfon	Alternative insecticides	Percent treated
Colorado	-	none	---	---
Arkansas	1,650	none	---	---
Alabama	6,000	120	Diazinon Sevin	5 3
Iowa	800	none	---	---
Indiana	9,000	very little	---	---
Louisiana	500	none	---	---
New Jersey	9,000	none	---	---
Tennessee	4,700	140	---	---
Ohio	18,100	---	Sevin Asana Monitor	95 30 10
North Carolina	3,000	---	Asana Thiodan Cygon	75 50 50
New York	no data Dylox is not used	no data	no data	---
West Virginia	no data	very little used	no data	---
Florida	no data	no data	Ambush Dipel Lannate Monitor Pydrin Thiodan	--- --- --- --- --- ---
Illinois	12,000	none	Pydrin Asana Thiodan Sevin	60 10 20 10
South Carolina	4,000	none	---	---

Sweet Corn

CURRENT USE ANALYSIS

Sweet corn is an important vegetable crop in the United States, and is grown for either fresh market (wholesale and retail) or for processing (canned and frozen) in all states except Alaska. A total of 642,054 acres of sweet corn is produced in the United States (Tables 7 and 8) with a total value of $423,804,426.

Table 7. Sweet corn acreage in the United States, 1985-1987.

State	Harvested acres	Total value ($)
Alabama	2,312	7,000,000
Alaska	----	---------
Arizona	1,490	1,689,030
Arkansas	545	618,030
California	15,860	22,201,000
Colorado	2,643	3,407,000
Connecticut	3,957	3,758,000
Delaware	6,120	6,940,080
Florida	40,476	54,073,000
Georgia	4,753	5,389,902
Hawaii	195	211,130
Idaho	23,330	26,456,220
Illinois	41,319	3,118,000
Indiana	7,355	8,340,570
Iowa	5,619	6,371,946
Kansas	883	1,001,322
Kentucky	1,322	1,499,148
Louisiana	792	898,128
Maine	1,685	1,910,790
Maryland	14,778	16,758,252
Massachusetts	7,289	10,339,000
Michigan	12,740	8,640,000
Minnesota	108,439	122,970,000
Mississippi	850	963,900
Missouri	1,729	1,960,686
Montana	181	205,254
Nebraska	443	502,362
Nevada	-----	---------
New Hampshire	1,688	1,914,912
New Jersey	12,738	11,300,000
New Mexico	1,411	1,600,074
New York	48,760	24,037,000
North Carolina	4,722	3,197,000
North Dakota	225	255,150
Ohio	14,480	15,075,000
Oklahoma	808	916,272
Oregon	48,258	4,026,000

Table 7. Sweet corn acreage in the United States, 1985-1987.--(Continued)

State	Harvested acres	Total value ($)
Pennsylvania	19,762	14,396,000
Rhode Island	1,147	1,300,698
South Carolina	1,612	1,828,008
South Dakota	270	317,520
Tennessee	1,296	1,496,664
Texas	3,622	4,107,348
Utah	1,042	1,181,628
Vermont	956	1,084,104
Virginia	3,167	4,624,000
Washington	52,305	4,528,000
West Virginia	740	839,160
Wisconsin	115,967	131,510,000
Wyoming	39	44,228
Total	642,054	423,804,426

Table 8. Value of fresh market and processing sweet corn in the United States, 1985-1987 average.

Use	Acreage	Value
Fresh market	211,184	181,489,000
Canning	265,000	90,986,000
Freezing	165,870	151,804,426
Total	642,054	423,804,426

Important sweet corn producing states include California (15,860 acres), Florida (40,476 Acres), Idaho (23,330 acres), Maryland (14,778 acres), Michigan (12,740 acres), Minnesota (108,439 acres), New Jersey (12,738 acres), New York (48,760 acres) Ohio (14,480 acres), Oregon (48,258 acres), Pennsylvania (19,762 acres), Washington (52,305 acres), and Wisconsin (115,967 acres), representing 81% of the total U.S. acreage. Of the 32 states surveyed for trichlorfon use, 22 of the states responded (69%) to the survey.

Only two of the states reported the use of trichlorfon on sweet corn: Tennessee (1375 acres) reported trichlorfon used on 3-5% of the acreage (42-69 acres) and Virginia (2900 acres) reported trichlorfon used on 5-10% of the acreage (145-290 acres), a total of 187 to 359 acres of sweet corn treated with trichlorfon in those states. Mobay Corporation reported that a total of 250 acres of sweet corn were treated with trichlorfon in 1986, thus the survey responses were accurate. Other responding states reported that no trichlorfon was used on sweet corn, and reported that trichlorfon is no longer in their insect control recommendations. However, many states have retained trichlorfon in their insect control recommendations, including Oregon, Washington, Idaho, New Jersey, Florida, Ohio, Indiana, Pennsylvania, Texas, Maryland, Virginia, Delaware, and New York. Based on results of the surveys, it is difficult to explain why so many states retain trichlorfon in their recommendations for insect control in sweet corn because only two states reported any usage of trichlorfon in sweet corn, (with a total of only 200-360 acres being treated in the all of U.S.) especially with the many insecticide alternatives available.

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PERFORMANCE EVALUATION AND ALTERNATIVES

Tennessee reported that trichlorfon was applied to sweet corn on an average of one application per acre at a rate of 0.25-0.5 lb a.i./A for control of cutworms and true armyworms. Virginia reported that 1-3 applications were used at a rate of 0.25-.05 lb a.i./A per acre for control of various cutworms. Both states reported that the use of trichlorfon resulted in 90-95% control of true armyworms and various cutworms attacking sweet corn using 1-3 applications at the 0.5 lb a.i./A rate.

Various species of cutworms and armyworms attack sweet corn, including the black cutworm (*Agrotis ipsilon*), the true armyworm (*Pseudaletia unipunctata*), the fall armyworm (*Spodoptera frugiperda*), the beet armyworm (*Spodoptera exigua*), the spotted cutworm (*Amathes nigrum*), the southern armyworm (*Prodenia eridana*), and the yellow-striped armyworm (*P. ornithogalli*).

Cutworms generally eat off the plants just above, or just below, the surface of the soil, causing the plant to wilt or fall over, particularly during the seedling stage. Some cutworms devour the foliage of the young plants or leave large ragged holes in the leaves. The majority of the cutworms pass the winter in the larval stage, although some overwinter as pupae or adults. Larvae start feeding in early spring, and can be very destructive to newly emerging corn seedlings, often causing entire fields to be replanted.

Although one to several generations may occur per season, depending on species and location, these pests are most destructive to sweet corn during the seedling stage and seldom cause problems to more developed corn.

Army cutworms and true armyworms often develop a gregarious marching habit of migration, eating young plants to the ground or stripping the foliage off mature plants. Armyworm outbreaks are associated with fields that are excessively grassy or fields of small grains or grasses, especially where the grains have fallen over or lodged, thus damage usually starts at the edges of the field, where the worms move in from another crop.

Various methods of non-chemical control are often used successfully in a cutworm and armyworm management program, including crop rotation, clean cultivation to eliminate grasses and other weeds, and by avoiding planting into fields that have a history of excessive moisture or flooding. Also, several species of parasitic flies, wasps and ground beetles attack armyworms and cutworms, helping reduce the population, although this often occurs after the damage has been done.

Table 9. Alternative insecticides used on sweet corn for the control of true armyworms and cutworms.

Material	Rate range lb a.i./acre	Dollar range Cost/application/acre
True Armyworms and Cutworms		
trichlorfon	0.5-1.0	2.80-5.60
carbaryl	1.0	3.77
es-fenvalerate	.03 -.05	4.06-6.76
fenvalerate	0.1-0.2	3.94-7.98
methomyl	0.45	6.12
permethrin	0.1-0.2	3.28-6.56
methyl-parathion	0.5-1.0	4.19-8.38
chlorpyrifos	0.5-1.0	3.75-7.50
EPN	0.5	2.70
Methoxychlor	1.0-2.25	6.97-15.68
malathion	1.0-1.25	2.24-2.80
thiodicarb	0.5-0.75	7.30-10.95
parathion (armyworm only)	0.5-1.0	1.17-2.34
<u>Bacillus thuringiensis</u> (armyworm only)	0.5-1.0	5.40-10.80
Preplant Applications (cutworms only)		
diazinon	2.0-4.0	12.00-24.00
fonophos	4.0	31.80
carbofuran	1.0-1.5	10.37-15.56
ethoprop	1.0-1.5	12.13-18.20
chlorpyrifos	1.0-2.0	7.50-15.00
phorate	0.5-1.25	3.08-7.69

ECONOMIC ANALYSIS

Both Tennessee and Virginia reported that trichlorfon was effective and economic when used to control armyworms and cutworms. Both states reported that up to 90% control is obtained using 1-3 applications of trichlorfon, at a cost of $2.80-5.60 per application. Equally effective treatments reported by the surveyed states included carbaryl (3.77 per acre), es-fenvalerate ($3.94-7.98), methomyl ($6.12), permethrin ($3.88-6.56), fenvalerate ($3.38-6.76) and foliar sprays; one pre-plant application of any of several alternative insecticides is comparable in both efficacy and economics.

The low rate of trichlorfon is comparable to the costs of most of the alternative insecticides on sweet corn. Trichlorfon at 0.5 lb a.i./A is $1.14 less than the low rate of fenvalerate (0.1 lb a.i.), $ .48 less than the low rate of permethrin (0.1 lb a.i.), and $ .95 less than the low rate of chlorpyrifos. However, Virginia reported that the higher rate of trichlorfon was generally used (1.0 lb a.i.) and Tennessee reported that a rate between the low and high rates was used (0.8 lb a.i.). Thus, little economic benefit is obtained strictly as a result of the use of trichlorfon as compared with the alternatives since all of the materials were reported to be equally effective. Although trichlorfon is reported to be relatively safe to beneficial insects, this advantage is often lost since most treatments are applied early in the season before many beneficials are present in the corn fields.

SUMMARY

A total of approximately 200 lbs a.i. of trichlorfon (see p.42) is used annually on sweet corn in the United States, applied to a maximum of 359 acres each year of the 653,777 acres of sweet corn. Of the 32 states surveyed, only 2 states reported any use of trichlorfon on sweet corn: Virginia and Tennessee. These states reported that trichlorfon was used for control of various species of armyworms and cutworms. The cost of trichlorfon is comparable to the costs of many of the alternatives for an equal level of insect control, and it is apparent that trichlorfon has no distinct advantages over the available alternatives. The loss of trichlorfon would result in no significant economic impact (reduction in quality or quantity of yield) on the assumption that the alternatives are available. Of the currently available alternatives, methomyl, thiodicarb, carbaryl, chlopyrifos, are effective and economic for control of armyworms and cutworms.

Insecticide Alternatives (including Trichlorfon) in Alfalfa Seed Production and Their Impact on Commercial Alfalfa

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I. Overview of Alfalfa Seed Production the United States

U.S. alfalfa seed production is concentrated in California and the other western states of Idaho, Washington, Nevada, Oregon, Montana and Utah. Minor and erratic "catch crop" seed production does occur in the Great Plains region including Oklahoma, Kansas, Nebraska, South Dakota and North Dakota. However, the far west dominates in management-intensive, technologically-advanced alfalfa seed production. This dominance is attributed to several factors: 1) Arid climates suitable for pollinating bees and seed harvest; 2) conducive soils; and 3) dependable and relatively low-cost irrigation water supplies. A highly competitive infrastructure comprised of specialized growers, seed conditioners, and private alfalfa breeding firms has developed, tapping the favorable natural resources that exist in areas of the western United States.

The strategic importance of the seed industry infrastructure to U.S. forage production needs to be emphasized. Estimates from USDA/NASS ranked alfalfa hay in 1987 as one of the top U.S. commodities both in area of production (25.5 million acres) and value of production 5.61 billion dollars (Table 10).

The alfalfa seed component supports a large forage industry. Alfalfa hay crops must be replanted periodically to achieve maximum yield and quality. Seeding rates vary, but can require as much as 20 lbs. of alfalfa seed per acre of hay. This support comes not only from supplying common seed but from supplying a high quality seed of genetically improved varieties adapted to all the important geographic areas of forage production. Over 150 improved varieties have been developed with unique winter hardiness and pest resistance characteristics. Seed from all of these varieties are produced in the west and marketed throughout the nation. All of the major alfalfa breeding firms have research and seed production operations in the west including Northrup King, Pioneer Hybrid, AgriPro, and W. L. Research.

California is the largest seed producing state in the U.S. and produces seed alfalfas for the non-hardy, semi-hardy and winter-hardy markets. The northwest is second in overall production but dominates in the production of semi-hardy and hardy types of alfalfas. Table 11 summarizes recent seed production statistics and Table 12 reveals the scope of the seed industry infrastructure in the west.

The size of the alfalfa seed industry is relatively small - 150,000 acres in the major production states and produced roughly 80 million lbs. of seed. Nationwide around 93 million lbs. of seed was produced in 1988 with a farm gate value of around $100 million. The strategic importance of the commodity in providing a reliable, efficient source of improved alfalfa varieties to U.S. agriculture should not be overlooked.

In any assessment of oxydemeton-methyl, trichlorfon, mevinphos and naled in alfalfa production systems, this strategic factor should be included in the overall risk benefit equation.

Table 10. Recent U.S. forage alfalfa statistics.[1/]

U.S. Alfalfa and Alfalfa Mixture for Hay

Year	Acres	Average Yield T/A	Production Tons
1985	25,608,000	3.32	85,048,000
1986	26,793,000	3.42	91,552,000
1987	25,485,000	3.32	84,554,000

Estimated Production Value of Alfalfa and Alfalfa Mixture Hay

Year	Production Tons	Average Price	Total Value
1987	84,554,000	$66.40	$5.6 billion

Alfalfa Ranks as a Top U.S. Commodity

1 - Corn (grain)	$12.1 billion
2 - Soybeans	$10.4 billion
3 - Alfalfa	$ 5.6 billion
4 - Wheat	$ 5.4 billion
5 - Cotton	$ 4.6 billion

[1/]Derived from USDA/NASS data.

Table 11. 1988 U.S. alfalfa seed production.[1]

Regular Production States

State	Acres Harvested	Yield Per Acre Lbs	Production Clean Lbs
California	69,000	599	41,320,000
Idaho	35,000	475	16,625,000
Washington	26,000	450	11,700,000
Oregon	10,000	475	4,750,000
Nevada	9,500	500	4,750,000
Total	149,500		79,145,000

Variable Production States

State	Production Clean Lbs
Montana	2,500,000
North Dakota	1,000,000
South Dakota	5,000,000
Nebraska	1,250,000
Kansas	4,000,000
Total	13,750,000

[1] Statistics from California Crop Reporting Service, Seed Certification Agencies and industry sources.

Table 12. Alfalfa seed infrastructure in California and the Northwest.[1/]

State	Number of Growers	Number of Companies Conditioning and/or Marketing Alfalfa Seed
California	125	17
Idaho	600	12
Washington	95	7
Oregon	100	5
Nevada	30	2
Montana	100	20
Total	1,050	63

[1/] NAPIAP survey, Fall 1988.

II. Integrated Pest Managment Approach to Alfalfa Seed Production

Production of alfalfa seed is a highly specialized and management-intensive enterprise. Three essential components of management include: 1) control of detrimental insects; 2) supply of effective bee pollinators; and 3) skillful application of irrigation water when alfalfa plants are flowering. In the western production areas control of detrimental insects is accomplished through integrated pest management systems. In 1973 Washington State University Extension Service initiated a highly successful alfalfa seed IPM project. Similar programs were started by Oregon State University, University of Idaho, and University of Nevada Extension Services in 1976. University of California Cooperative Extension has developed programs unique to the south San Joaquin Valley production area.

Particularly in the northwest region, the basic objectives of training pest management personnel, implementing improved pest control programs and turning IPM services over to the private sector have been achieved. A truly unique feature of the IPM systems is the development of monitoring techniques and improved management procedures for the essential bee pollinators.

Alfalfa seed IPM systems include the classic components of 1) weekly sampling to monitor pest and beneficial insect populations, 2) use of research derived economic thresholds, 3) conservation of beneficial insects and 4) selective use of pesticides.

In 1988 a survey of growers and seed company fieldmen in Idaho, Washington, Oregon and Nevada revealed that nearly 100% practice some form of IPM on their farms. Prior to the development of IPM programs in the northwest it was not uncommon for seed fields to receive 8-10 applications of insecticides per season. Now IPM growers typically apply 1-5 insecticide treatments per year. Grower-adopted IPM methods have resulted in 1) better timing of applications based on accurate counts of various stages of the pests, 2) reduced disruption and increased utilization of beneficials, 3) elimination of unnecessary treatments and 4) improved conservation of pollinators.

Alfalfa Seed IPM systems are continually being refined due to the ongoing efforts of university researchers, extension personnel, seed company fieldmen and consultants. IPM technology transfer reaches growers through an effective information network including annual regional and local commodity meetings, seed company meetings, and newsletters and extension publications. The success of IPM on this commodity is in serious jeopardy due to the crisis of pesticide registration and re-registration on a minor use crop such as alfalfa seed. Table 13 summarizes the registration record of alfalfa seed during the period 1987-1988. Loss of registration of pirimicarb and demeton, two selective aphicides, has seriously strained IPM on alfalfa seed. The short residual organophosphates, oxydemeton-methyl, naled, mevinphos and trichlorfon, are currently the cornerstones of the insecticide component of pest control in Northwest seed production. They provide the short residual control of primary and certain secondary pests during the flowering period when pollinators are active.

The loss of these compounds due to the economics of re-registration or for toxicological reasons would devastate alfalfa seed IPM in the northwest region.

Table 13. Northwest Alfalfa Seed Registration Record 1978 - 1988.[1/]

	Cancellation	New Registration	Under Special Review or Re-registration Review
Insecticides			Carbofuran (Furadan)
	Pirimicarb (Pirimor)	Chlorpyrifos (Lorsban)	Oxydemeton-methyl (Metasystox-R)
	Demeton (Systox)	Permethrin (Ambush)	Naled (Dibrom)
	Toxaphene		Mevinphos (Phosdrin)
			Trichlorfon (Dylox)
			Parathion
Acaricides	Chlordimeform (Fundal)		
Herbicides	Chlorthal dimethyl (Dacthal)	Sethoxydim (Poast)	
	Chlorpropham (Furloe)	Bromoxynil (Buctril)	
	Simazine (Princep)		
	Hexazinone (Velpar)		
Dessicants	Dinoseb (Dinitro)		
Total	9	4	6

[1/]Sec. 18 Emergency Registrations not included.

III. Alfalfa Seed Pollination

Alfalfa must be cross pollinated to produce commercial amounts of good quality seed. Insect pollination is the only important method by which cross pollination occurs. There are three principal pollinators of alfalfa seed. Honey bees are used almost exclusively in California. Growers in the northwest alfalfa seed producing areas depend almost entirely on two species of wild bees, the alkali bee (Nomia melanderi) and the alfalfa leafcutting bee (Megachile rotundata). Table 14 reveals the relative importance of the three bees in the principal production regions. About one-third of all seed production in the U.S. and more than three-fourths of all seed of hardy alfalfa varieties is dependent on the two wild bees.

In California a minimum of 4 to 5 strong honey bee colonies per acre is recommended. However since only small amounts of oxydemeton-methyl, naled, mevinphos and trichlorfon are currently being used in this state the impact of these insecticides on pollination management is inconsequential.

In the Northwest the situation is very different. Honey bees do not pollinate alfalfa. The two wild bees, the alkali and the alfalfa leafcutting bee, though solitary will nest gregariously and are oligolectic on alfalfa. They are very efficient pollinators of alfalfa.

Since their initial description and adaptation to alfalfa seed production 3-4 decades ago they have gradually become semi-domesticated bees. Management techniques have been developed which integrate the biology of the two species with overall seed production systems. Today a multi-million dollar industry is built around providing nesting materials, domiciles, predator and parasite traps and the raising of the two bees particularly the alfalfa leafcutting bee.

The use of these pollinators has increased yields 3 to 5 fold, and 1,000 lbs. per acre seed yields are not uncommon. The success and survival of the northwest alfalfa seed industry is dependent on the alkali and leafcutting bee.

The alfalfa leafcutting bee nests in small holes drilled in wooden boards or other suitable nesting materials. The bee boards are stacked in small buildings or domiciles which are placed directly in fields during the pollination period. Flowering occurs from mid-June to mid-August with peak pollination activity usually in July. The life span of the female leafcutting bee is about 5-6 weeks. Synchronizing the life cycle of the bee with the bloom period of alfalfa is extremely critical to produce an economically viable seed crop. During the bloom period the bees develop a strong orientation to the fields in which they are nesting. Movement of the domiciles during this critical period is disruptive to bee orientation and can result in loss of bees, reduced seed set, and lower yields.

For these reasons it is not generally practical to protect bees from required insecticide treatments by moving domiciles out of the fields until the chemicals degrade to safe levels. Growers maintain leafcutters as essentially resident, fixed populations in fields or cluster of fields. To make this successful, growers must avoid treatments with longer residual insecticides that would be hazardous to pollinators.

Current university recommendations suggest maintaining 7-10 thousand female leafcutting bees per acre to optimize yields. Grower inputs for bees and handling costs can reach as high as $173/A. and represent 32% of the total per acre cost.

Alkali bees are used primarily in the Gardena-Touchet region of Washington and in Nevada. The alkali bee is the most effective pollinator of alfalfa seed of the three types of bees currently used. However, it is also the most difficult to manage. They are soil nesting bees with rigid requirement for soil texture, moisture and salinity. These bees are managed in natural or artificial bee beds located adjacent to seed fields. They obviously can not be moved to avoid hazardous insecticide treatments. The availability of short residual, safe, insecticides is essential in the production areas that have adopted this pollinator. Alkali bee beds with 1 million nesting females per acre can provide excellent pollination for nearly 200 acres of alfalfa. In the Gardena-Touchet area, costs for managing alkali bees are around $10/A.

Two of the three essential management components of seed production, control of insect pests and supply of effective pollinators, set up a serious dilemma for the seed producer. How can the alfalfa seed grower control seed-destroying pests while maintaining an adequate pollination force required for economic yields? The necessary delicate balance is being achieved by using IPM methods and selective short residual insecticides, oxydemeton-methyl, naled, mevinphos and trichlorfon. These four compounds are being used cautiously to control pests during the critical flowering period. Treatments are applied exclusively after sunset or at night when the pollinators have generally returned to their nests. The short residual properties of these chemicals reduce the post-treatment hazards to bees (Table 14). Loss of registration of pirimicarb and demeton, two relatively bee-safe selective aphicides, has placed a strain on pollinator-pest management systems. The cumulative loss of oxydemeton-methyl, naled, mevinphos and trichlorfon without replacement with materials of similar selectivity and bee safety would have grave consequences for the northwest alfalfa seed industry. Table 16 summarizes characteristics of the insecticides in relation to the alfalfa leafcutting bee and the alkali bee.

Table 14. Relative importance of pollinator species in alfalfa seed production.[1/]

	% of Production Dependent on Bee Species		
	Honey Bee	Alfalfa Leafcutting Bee	Alkali Bee
California	99	1	0
Idaho/Oregon	0	99	1
Washington			
Gardena/Touchet	0	30	70
Columbia Basin	0	97	3
Nevada	5	75	20
Montana	0	100	0

[1/] NAPIAP Survey, Fall 1988.

Table 15. Mortalities of alkali bees (AB), and alfalfa leafcutting bees (LB) exposed to 12 hour residues of insecticides.[1/]

Insecticide	lbs a.i./A	24 hr % mortality of bee caged with treated foliage	
		AB	LB
Trichlorfon	1.0	6	5
Oxydemeton-methyl	0.75	27	2
Naled	1.0	0	18
Mevinphos	0.5	10	6

[1/]Data from "Integrated Pest and Pollinator Investigations 1988 D.F. Mayer, J.D. Lunden, E.R. Miliczky, Department of Entomology, IAREC, Washington State University.

Table 16. Toxicity of pollination (bloom) period insecticides to wild bees.[1/]

Insecticides	Recommended Rates lbs a.i./A	Leafcutting Bee	Alkali Bee	Comments
		Length of Residual Toxic Effect		
Naled	0.75	12 hrs	12 hrs	Not generally recommended as bloom treatment because of bee hazard! Under special environmental conditions it is used during pollination period.
Trichlorfon	0.5-1.0	2-5 hrs	6-14 hrs	Less effective control [1/] lygus bug due to resistance. Use for lepidopterous pest.
Mevinphos	0.25-0.5	5 hrs	5 hrs	Toxicity Level I to applicators. Primarily late season use against lygus.
Oxydemeton-methyl	0.5	4 hrs	2 hrs	Bee safe, effective against lygus bug early season.

[1/]Based on data in WREP 15 "How to Reduce Bee Poisoning from Pesticides" revised October 1988. Washington State University.

IV. Comparative Efficacy of Oxydemeton-methyl, Naled, Mevinphos, Trichlorfon to Primary and Secondary Pests.

Management of detrimental insect populations is essential to successful alfalfa seed production. Lygus bugs are the most serious pests of alfalfa seed and considered primary pests in California and the northwest. Two principal species are involved: Lygus elisus and L. hesperus (Hemiptera:Miridae), of which both the immature nymphs and adults feed on alfalfa. There are several types of injury produced by feeding lygus bugs. They have sucking mouthparts and physically damage the plant by puncturing the tissue and sucking the plant juices. There is also a toxic reaction from the saliva of the insect. Greatest damage is caused when lygus bugs feed on the flower buds. Injured buds turn tan to white, die and fall from the plant within 2-5 days. Lygus bugs also feed on immature seeds. The pod is pierced and the juices are sucked from the developing seed. Seeds turn brown, later nearly black, shrivel and will not germinate.

Most lygus bug damage and potential crop yield loss occurs during the critical flowering and early pod development stages. This coincides with maximum pollinator activity in the fields. In the northwest, the control of lygus bugs is achieved with treatments of Oxydemeton-methyl, naled, mevinphos, or trichlorfon. All of these insecticides are sprayed after sunset to reduce bee mortality to a minimum. Unfortunately, there are no effective control measures for lygus bugs on alfalfa seed except for insecticides.

Secondary pests that also cause damage during the flowering-pollination period include aphids, loopers, armyworms, cutworms and spider mites. Table 17 summarizes primary and secondary alfalfa pests during the flowering-pollination period of the crop.

The four insecticides under review are all valuable insecticide tools in an overall IPM approach to alfalfa seed production. Each has advantages, disadvantages, and unique properties which impart the selectivity needed in making difficult treatment decisions. The comparative efficacy of these insecticides cannot be evaluated against each another, for a single pest species. Rather their relative utility must be judged in the context of a complex pest-pollinator management system with its subtle overlay of environmental factors. Treatment decisions in alfalfa seed IPM, particularly during the flowering-pollination period, include several considerations:

1. Primary pest levels and thresholds.
2. Secondary pest levels and thresholds.
3. Species of pollinating bee utilized.
4. Pollinator density and bee age.
5. Levels of beneficial insects.
6. Stage of crop development, i.e. early flowering, late flowering, early pod development.
7. Irrigation scheduling.
8. Method of application, ground or air.
9. Evidence of pest population resistance to insecticides.

10. Weather conditions, including wind velocity, night time temperatures, relative humidity and presence or absence of dew on canopy.

For example, oxydemeton-methyl is frequently used as the first bloom treatment against lygus bugs but it loses some efficacy against lygus as the season progresses. Later season lygus treatments of mevinphos or naled are common but warm evening temperatures and absence of dew on the canopy are critical to avoid bee kills. Trichlorfon is the primary lygus treatment in Montana, but resistant populations of lygus in the other Northwest states have reduced its use significantly. Trichlorfon is however a selective bee-safe treatment against secondary lepidopterous pests throughout the northwest. Oxydemeton-methyl does provide some suppression of spider mites but is not effective for controlling occasional outbreaks of loopers or armyworms. There are differences among the four insecticides with regard to impact on beneficial insects. None of the four insecticides can control outbreaks of the spotted alfalfa aphid.

The factors of field status, pest outbreaks, weather condition and other treatment considerations vary not only from season to season but week to week. The availability of insecticidal products with different efficacy against the spectrum of pests present with alternative modes of action, routes of detoxification, residual life, and possibility for use with reduced impact on beneficials is critical to a successful IPM approach. Table 18 compares the available insecticides for the flowering-pollination period.

Suppression of lygus bugs as well as other secondary pests is essential to achieve economic yields. Control of detrimental pests can enhance yields 5-10 fold. Interaction of lygus control and seed yield has been well documented by researchers since the late 1950s. Two recent research projects clearly exhibited the relationship between pest suppression and yield. Data in Table 19 reveal how even a single treatment of oxydemeton-methyl during the flowering period increased yield by more than 50%. This represents nearly a $160/A. jump in the value of production. No other pest control treatments were applied on these replicated experiment station plots during the course of the experiment.

A total alfalfa seed management study, conducted by Oregon State University researchers from 1985-1988, gave further evidence of the yield benefits of IPM. IPM under two irrigation regimes yielded 3.8X and 2.7X higher production over the untreated control (Table 20). Both naled and oxydemeton-methyl were applied to suppress lygus and aphids in that study.

Table 17. Primary and secondary insect and mite pests of northwest alfalfa seed during flowering pollination period.[1/]

Common Name	Scientific Names	Comments
Primary Pest		
Lygus Bug	Lygus elisus Lygus hesperus	Stresses plants, damages flower buds, flowers and developing seed. Progressively more difficult to control during course of season. Must be treated 1-3 times per season.
Secondary Pests		
Pea Aphid	Acyrthosiphon pisum	Found in all production areas. Heavy infestations stunt and wilt plants. Large amounts of honeydew produced. Can cause premature flower drop. Exceeds treatment threshold usually once per season.
Blue Alfalfa Aphid	Acyrthosiphon kondoi	Newly introduced aphid in northwest. Similar damage as pea aphid but more severe at lower numbers. Only occasionally needs treatment.
Spotted Alfalfa Aphid	Therioaphis maculata	Found in all production areas. Secretes plant toxin while feeding. 20-40 aphids per plant can cause severe injury. Produces large amounts of honeydew. Susceptible alfalfas usually treated once or twice per season.
Alfalfa Seed Chalcid	Bruchophagus roddi	Tiny wasp larvae that consume seed contents. Difficult to control with insecticides. Cultural controls are the key. Some evidence that adult control with OPs may help.
Alfalfa Weevil	Hypera postica	Larvae defoliate and destroy buds. Common prebloom pest. On rare occasions late hatch causes problem during flowering.

(Table 17 continued)

Common Name	Scientific Name	Comments
Looper, Armyworms, and Cutworms	_Trichloplusia ni_ _Mamestra configurata_ _Spodoptera sp_ _Euxoa sp_.	Occasional localized outbreaks can be severe. Cyclical outbreaks every 5-7/yrs. Defoliates and clip off flowers and pods. Late instars very difficult to control.
Spider Mites	_Tetranychus urticae_ _Tetranychus pacifica_	Stippling damage on leaves and buds. Heavy infestations stress plants and webbing interferes with pollination. Usually late season pest near end of pollination period. Usually treated once per season every other year.
Grasshoppers	Several species	Cyclical outbreaks every 7-10 years.

1/Information from Alfalfa Seed Insect Pest Management, WREP 0012, May 1979. Washington State University.

Table 18. Effectiveness of insecticides use in the Northwest during flowering-pollination period.

	Rates lb a.i./A	Effect on Lygus Bugs	Effect on Other Pest	Impact on Beneficials	Other Advantages or Disadvantages
Oxydemeton-methyl	0.375-0.5	Excellent on early season lygus, good to fair on late season lygus.	Good on pea aphid. Some mite suppression.	Moderate	Systemic action. Relatively bee safe.
Naled	0.5-1.0	Very good on late season lygus.	Good on grasshopper. Fair on lepidopterous pests.	Severe	High bee risk. Weather conditions need to be carefully monitored when applying.
Mevinphos	0.25-0.5	Very good on late season lygus.	Good on Grasshopper. Fair on alfalfa weevil. Some use to suppress chalcid.	Very Severe	Ralatively safe on bees. High applicator hazard.
Trichlorfon	0.5-1.0	Poor on lygus except in Montana and other select areas.	Very good on small lepidopterous pest.	Moderate	Relatively bee-safe. Resistance problem with lygus.
Permethrin (1988 reg.)	0.1-0.2	Inconsistent on lygus.	Inconsistent on aphids.	Very Severe	Mite outbreaks following treatment. Seed specialists recommend against use because of high risk of bee kills.

Table 19. Interaction of 3 day post-treatment lygus control with seed yields, Malheur Experiment Station 1985.[1/]

Treatment	Lbs a.i./A	% Control Lygus	Actual Seed Yield Lbs/A	% of Check
Oxydemeton-methyl	0.5	92.4	358	155
Trichlorfon	1.0	58.7	269	116
Untreated Check	-	-	231	100

[1/]Unpublished data developed by Dr. Clint Shock, Malheur Experiment Station Superintendent and Ben Simko, Malheur County Extension Agent.

Table 20. The effects of insecticide control levels and irrigation stress on Wrangler alfalfa seed production. Malheur Experiment State University, Ontario, Oregon 1988.[1/]

Irrigation Stress	Insect Control	1985	1986	1987	1988	AV
		Yield by Year				
		--lbs/A--				
Non stressed	None	138	167	16	51	93
	IPM	252	828	65	255	340
	Weekly	214	902	138	379	408
	Average	201	632	73	228	284
Water stressed	None	272	195	58	201	182
	IPM	482	667	242	593	496
	Weekly	564	759	667	642	658
	Average	440	540	323	479	446
Combined	None	205	181	37	126	137
	IPM	367	747	153	424	423
	Weekly	389	830	402	510	533
Overall Mean		320	830	402	510	365
LSD (.05) Irrig. Stress		69	69	104	45	
LSD (.05) Insect Control		41	48	68	64	
LSD (.05) Irrig x Insect Control		68	68	79	91	

[1/] Pending publication in O.S.U. Agricultural Experiment Station Special Report, Dr. Clint Shock, Malheur Experiment Station Superintendent, O.S.U. and Dr. Bill Stephen, Department of Entomology, O.S.U.

V. Lygus Bug Resistance to Insecticides

The main pest of alfalfa seed in the northwest is the western legume bug, lygus bug, *Lygus hesperus*. While other species are present in the fields of Utah, Idaho and Oregon, *L. hesperus* is the species we (Simko and Brindley) have concentrated upon. *Lygus elisus* numbers tend to increase with presence of weeds in the fields or at the field borders.

Alfalfa seed growers of Oregon and Idaho, and the Delta, Utah region, have complained of possible resistance of lygus bugs to trichlorfon for a number of years. These problems are a major factor in the fall of trichlorfon from once being the most preferred to presently one of the least used insecticides in northwestern alfalfa seed production (Table 24). We (Simko and Brindley) have confirmed that resistance has developed from the following evidence: 1) comparison of trichlorfon efficacy by bioassy from regions of no and high insecticide use; 2) correlation between LC_{50} and efficacy of trichlorfon on field plot trials by ground-spray rigs; 3) finding that DEF, an effective inhibitor of esterases, markedly lowers trichlorfon LC_{50} values; 4) correlating trichlorfon LC_{50} values to esterase activity.

Developing Tests for Resistance: Our (Simko and Brindley) concern has been that effective control of lygus bugs on alfalfa seed crops is only feasible with effective, short-lived, insecticides that spare most beneficial arthropods. It is particularly important that the pollinators be spared since they must be kept in the fields at the same time that much of the lygus bug control is effected.

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Too many of the alternative insecticides, pyrethroids or the more toxic organophosphates for example, are likely to be damaging to leafcutting, alkali, or honey bees. Considerable economic and labor investments are made in these pollinators. Few insecticides meet all of these criteria and loss of them by either target pest resistance or regulatory decision would place the alfalfa seed industry in serious difficulty.

Each step of the control evaluation process has therefore included field studies in Utah, Idaho or Oregon and laboratory studies at Utah State University using field-collected samples of <u>Lygus hesperus.</u> Care has been taken to design methods that are not only meaningful for laboratory research, but which can also be used directly in the field. Because of the well-organized IPM systems for alfalfa seed production in the northwest (Section II), researchers felt the economic role of trichlorfon and other insecticides used on the crop would be optimized if growers had baseline data and convenient methods to estimate possible resistance and probable efficacy. Application of these methods would enhance the economic return with use of the insecticides while minimizing environmental and exposure impacts.

This approach has been successful. Simko and Brindley are ready to recommend methods for IPM surveillance which include 1) bioassay, 2) bioassay with synergism, 3) spot tests for the resistance-conferring esterases of <u>L. hesperus</u>, or 4) combinations of esterase tests and synergism.

Biological Assays and Synergism: The purpose of the bioassays is to provide a quantitative estimate of the degree of susceptibility, tolerance, or resistance of the lygus bug population. The data are represented as LC (lethal concentration) values to kill a particular percentage of pests sampled. The LC_{50}, the amount of insecticide required to kill half of the population sample, is the most commonly used LC value. Bioassays are the most demanding of these steps. They require a portable incubator (easily built for less than $150) (Brindley et al., 1981) and a kit of pre-coated glass vials (Brindley, 1975) or disposable "zip-lock" bags. If the bags are used, researchers estimate the cost of one bioassay kit to be about $1 and hence easily disposable. The recommended bioassay period is 8 hours. The bioassay with bags works well with trichlorfon and oxydemeton-methyl, and has possibilities with naled. The possible alternative insecticides, permethrin, baythroid and bifenthrin also may be tested in the bags.

Bioassay with synergism requires two extra sets of vials or bags, extra sampling, and another hour. The only variation is that half of the insects sampled are subjected to a regular bioassay and the other half are first exposed to a chemical (synergist) which might inhibit or block a resistance mechanism. If that blocked resistance mechanism was solely responsible for the resistance, the LC_{50} value observed should be similar to that of a susceptible population. If the resistance mechanism indicated by the synergist is important but there is another mechanism as well, the new LC_{50} will be lowered but not lowered to the level of a susceptible population.

The bioassay kits give the alfalfa seed IPM system a means of not only estimating the magnitude of resistance but also of suggesting (Brindley and Selim, 1984) the reason for the resistance. This gives those wishing the full economic advantages of insecticide use, a simple, practical, yet sophisticated tool for characterizing their populations before spraying begins.

Spot Tests for Esterases: The bioassays and synergism, confirmed by laboratory biochemistry, show that *L. hesperus* resistance to trichlorfon is due to enzymes called esterases. This is a common resistance mechanism against organophosphate insecticides. Researchers have no evidence that other detoxication systems (MFOs, GSTs) are involved. As will be explained later, a strain of *L. hesperus* which has higher esterase levels plus a form of acetylcholinesterase (the enzyme attached by organophosphates as the insect is killed) which resists poisoning, has now become a factor in alfalfa seed protection.

Spot tests for esterases require no incubator and can be accomplished with small, inexpensive kits. Lygus bugs caught in the field are frozen with dry ice and crushed between two filter papers. The filter papers had been treated previously with a chemical that will be attacked by esterases inside the lygus bugs. If the esterase level is high, a definite color change will appear when a proper dye is placed on the crushed insect. The color readings are taken from one piece of the filter paper; the other filter paper can be returned to a laboratory for more detailed analyses by biochemical methods if that is desired.

The spot test takes approximately 15 minutes to complete and, with modest care, can be done at the field site or later with frozen (or even dried) samples of lygus bugs.

As with bioassays, synergism can be used with the spot tests. Half the population sample is pretreated with the synergist DEF and the spot test is perfomed on both the pretreated and regular insects. If the color changes upon addition of the dye to a crushed, pretreated insect, that insect probably was of the new, combined, resistance form. Simko and Brindley would caution readers that these data though based on a lot of observations, are preliminary, and final verdict will be rendered in the near future.

There are 3 important advantages of the spot tests. First, they are more rapid and secondly they are less expensive. The greatest importance is that they improve sampling and statistical efficiency by providing data from each individual. Thus, the proportion of each response type (susceptible, resistant, highly resistant) can be estimated in the populations. Theoretical models of how resistance changes with cultural and ecological factors in agriculture generally rely upon the numbers of pests and the proportion of resistant or susceptible individuals. This provides a good transition between practice and theory. Biological assays, on the other hand, are estimates drawn from populations and not from individuals. They require much more sampling but tend to give the "bottom line" in terms of toxicity. There are fewer correlations that are necessary to use bioassay data effectively in resistance management. If sampling efficiency is a major barrier, bioassays can be simplified to "discriminating assays" in order to reduce sampling needs.

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Impact of Resistance Detection upon Economics of Insecticide Use: The economic advantages of trichlorfon and other insecticides could be enhanced by resistance-detecting methods. IPM firms could base their decisions for insecticides on Lygus, and avoid unnecessary selection pressure toward higher resistance levels, incorrect selection of alternative insecticides. Extra disruption of biological control agents could be lessened.

Insecticide recommendations could be better tailored to local conditions, emergence of new strains of resistant pest could be more readily detected, and grower awareness of the resistance problem would be increased if tests for resistance were part of IPM programs. There would be added incentive for determining resistance levels in beneficial, natural enemies of pests and for keeping detailed records of insecticide application histories. Failures of insecticides due to errors in application would be more readily identified as such. There would be quantitative criteria to judge rates of resistance development or spread.

Status of *Lygus hesperus* resistance in Utah, Idaho, Oregon: The best approach for integrating resistance detection into alfalfa seed IPM would be for IPM field scouts to test weekly collections by the spot test or the spot test plus synergism. IPM firms or Extension specialists could then conduct periodic bioassays or bioassays with synergism, matching these data to pre- and post-application pest and beneficial insect counts. In the case of trichlorfon, declining efficacy can be expected with LC_{50} values exceeding 1 microgram trichlorfon/vial or when the percent of insects showing a positive color reaction on the spot test papers exceeds 10.

The disposable bag bioassay is a newer method but it appears that the threshold for efficacy with trichlorfon is approximately 4 micrograms trichlorfon per bag. If Lygus hesperus populations are susceptible to trichlorfon, then adequate control can be achieved with less than 1 lb a.i./A. If resistance has been established, not even 3 lb a.i./A will suffice. If the LC_{50} values have increased from 1 ug to 2 ug trichlorfon per vial, application of the insecticide will not give an optimal, economic return. A "resistance factor" of only 2 may seem implausible but it is real.

Lygus hesperus resistance can be very localized and prior testing is necessary. Regional generalizations are difficult to rely upon. For example, we have found adjacent fields, cultivated by the same grower, with LC_{50} values of 1 ug/vial on the one hand and 9 ug/vial on the other. Field efficacy trials and esterase test matched the bioassay results. Such local variations may help explain why some growers in apparent resistance areas still use trichlorfon. Another possibility is that early in the season, or in fields within the migration range of Lygus hesperus where the insects are actively migrating from alternate host plants that are becoming senescent, there can be decreases in the frequency of resistant individuals. Fields exposed to immigrating lygus bugs may thus have enough susceptible insects to reduce population nubmers below the economic threshold with an insecticide that might be ineffective later in the season, or to be so located as to receive fewer susceptibles. Local differences are responsible, in part, for ranges in LC_{50} values found among Lygus hesperus populations (Table 21).

Table 21 illustrates three time periods of bioassay trials for trichlorfon with Lygus hesperus. Regional differences (Utah: general susceptibility, Oregon/Idaho: general resistance) are apparent. Growers reports, have proved quite accurate. Generally speaking, toxicology measurements by researchers have matched grower experience and IPM records.

The data of Table 21 indicate a further problem, however. Notice the extremely high LC50 values for Trichlorfon (bag assay) data collected in the summer of 1988. Through the summer of 1987 IPM managers found more naled had to be used to be effective. By fall, 1987, in a field near Nampa, Idaho, a full-rate application of naled failed. Simko and Brindley analyzed that incident using trichlorfon bioassays and synergism. Even though the insecticide sprayed and the insecticide used for analysis were different, it was clear that a change may have taken place in the Lygus hesperus population. Simko and Brindley now have evidence that a new resistance mechanism has appeared. It is possible that higher levels of carboxylesterases and of acetylcholinesterases resistant to inhibition by paraoxon were developing. If those indications are correct, it will be disturbing for organophosphate usage as combinations of metabolic (as esterases) and target site (as acetylcholinesterases) can be very difficult. Synergism bioassays also indicated a new trend in resistance.

Alternative Insecticides: Bioassays were conducted in 1988 on trichlorfon and five alternative insecticides, so that baseline data in Utah, Idaho, and Oregon are being accumulated for trichlorfon, naled, ODM, permethrin, bifenthrin, and baythroid.

The latter 3 are pyrethroids. Future studies with synergism, bioassays and enzyme tests upon target lygus bugs will indicate if there are logical patterns of insecticide alternation that might help redress resistance. The researchers plan to expand the range of alternative insecticide tests if funding can be found.

Table 22 provides an example of how IPM or Extension personnel might use these detection methods. An alfalfa seed farm in Malheur County Oregon, was selected and spot tests were performed periodically in 1987. Esterase levels increased in Lygus hesperus from May 20 to June 26. Immediately after June 26, split plots were treated with 0.375 lb a.i./A of ODM and 1 lb a.i./A trichlorfon. Oxydemeton-methyl and trichlorfon provided 97.3% and 42.7% control of lygus bugs, respectively. A subsequent spot test on August 21 showed the esterase level further elevated.

All populations of lygus bugs in Malheur County have strong resistance to trichlorfon. This correlates well with recent efficacy data from IPM records which shows no trichlorfon control of lygus bugs. As of 1987, no populations of oxydemeton-methyl resistant lygus bugs had been observed in Malheur County although Malheur County has lower proportions of extremely resistant Lygus hesperus (Table 22). Efficacy of oxydemeton-methyl remains at more than 90%.

Impact of Resistance upon Effects of Insecticide Cancellations:
Redressing resistance has some possibilities for natural cycles of high and low esterase levels in Lygus hesperus and migration into alfalfa seed areas from other host plants can provide at least early "windows" of better efficacy in some alfalfa seed areas.

Some alfalfa seed production areas, Montana for example, do not have resistance problems and maximum effort should be made to retain efficacy. If the presence of resistance in Idaho and Oregon is used to "excuse" or make trivial a decision about re-registration of these insecticides, it will deprive a viable seed area, such as Montana, of effective pest control tools.

The benifits of any bee-safe, lygus bug-controlling insecticide are greatly magnified in the context of resistance to any of the few insecticides which now serve that role. It is not easy to find alternative insecticides because of the ecological and biological requirements, the dearth of new insecticidal materials, and status of alfalfa seed as "minor" crop which reduces commercial interest in developing insecticide alternatives. The possible suspension of oxydemeton-methyl, naled, trichlorfon, or mevinphos would have long term impacts on continued progress toward an insecticide resistance management program for alfalfa seed production.

Section I emphasizes the tremendous value of the alfalfa seed crop as needed to replant ca. 25,000,000 acres of alfalfa and alfalfa mixtures for hay. Yet the seed acreage in the northwest is less that 150,000. Presumably, regions where Lygus hesperus resistance has not yet devloped could take on larger roles in alfalfa seed production if resistance itself begins to curtail effective insecticidal control. This will not be possible, however, if the registration process removes the option of insecticides. Lygus hesperus populations reach such high levels on blooming alfalfa that alternative cultural and biological controls are generally ineffective.

Table 21. Examples of bioassay results using glass vials or plastic bags with trichlorfon and adults of *Lygus hesperus*. See text for interpretations.

Date	Location	LC_{50} ug/Vial*				LC_{50} ug/Bag*			
		N	Mean	SD	Range	N	Mean	SD	Range
1980	Logan, Ut	1	0.7						
	Delta, Ut	8	3.2	3.2	.1-13.2				
	Nampa, ID	6	4.3	2.0	2.8- 6.6				
1984	Caldwell, ID	15	5.5	3.9	1.7- 9.5				
1988	Utah					5	6	4.9	4-13
	Idaho					2	507		277-737
	Oregon					3	187	13	177-202

Unpublished data of W.A. Brindley, B.C. Simko, others.
*LC_{50} values of 1 ug/vial or 4 ug/bag or less are characteristic of susceptible populations.

Table 22. Trichlorfon resistance levels of *Lygus hesperus* populations of a single alfalfa seed field, Malheur County, Oregon, 1987.

Esterase & Resistance Percentages from Spot Test Results

Date Tested	High Esterase & Resistance	Moderate Esterase & Resistance	Low Esterase, Susceptible
5/20	14.2	81.0	4.8
6/5	33.3	61.9	4.8
6/18	38.1	61.9	0.0
6/26*	57.1	42.9	0.0
7/21	76.2	19.0	4.8

Unpublished data, B.C. Simko, W.A. Brindley
*Plots sprayed after spot test with ODM or trichlorfon (see text)

VI. Annual use pattern and potential applicator exposure to oxydemeton-methyl, naled, mevinphos and trichlorfon

Survey data from California reveal the insecticides ODM, naled, mevinphos and trichlorfon are rarely recommended and if used represent a very small percentage of the total pounds of insecticides applied to alfalfa seed. The low level of use of these materials relative to the northwest is the result of several factors. 1) The pest complex in the cotton, safflower, alfalfa seed rotation of the South San Joaquin Valley pose much different challenges to pest management systems. 2) Populations of lygus bugs have developed significant resistance to older organophosphates including ODM and trichlorfon. Recently some evidence of lygus resistance to mevinphos has also been observed. 3) In California producers rely almost exclusively on honey bees to pollinate seed fields. Honey bees differ from leafcutting and alkali bees in insecticide tolerance and sublethal effects from exposure. This allows the use of a different array of compounds in the California IPM program.

In Fresno and Kings Counties, occasional use of mevinphos still occurs as a pre-harvest treatment after honey bee hives are removed from fields. In Glenn County, a minor seed production area in northern California, oxydemeton-methyl is still used. Some operators use leafcutting bees along with honey bees for pollination. In 1988 120-180 acres were treated with the 0.5 lb a.i./A rate of oxydemeton-methyl.

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In the northwest, where the application of these insecticides is still prevalent, use data is reported in Table 23. More than 75% of Oregon's alfalfa seed production is in Malheur County. This extreme eastern county is contiguous with the southwest Idaho production area. Production systems and crop rotations are very similar. To simplify the data tables the Idaho and Oregon data are combined.

Two distinct production areas exist in Washington. The Columbia Basin district and the Gardena-Touchet district have different management and rotation systems. The data from these areas are reported separately.

Estimates from 1988 rank oxydemeton-methyl as the most preferred treatment in alfalfa for lygus control with 42,861 lbs a.i. used in the northwest. Naled was second in amount used at 29,331 lbs a.i. Oxydemeton-methyl represents nearly 50% of all treatments targeted for lygus control during the flowering-pollination period (Table 24).

In most northwest production areas, alfalfa seed growers tend to apply insecticides themselves with field sprayers pulled by closed cab tractors. The Columbia Basin district in Washington is the exception with all four insecticides applied by aircraft. This preference for private ground application of treatments stems from strong evidence of better performance of the materials when sprayed 2-3' over the canopy with higher volume of spray. Better treatment timing is another advantage particularly when commercial applicators have a backlog of orders. The private applicator often can treat within 12 hours after making a decision based on the latest pest and beneficial counts (Table 25).

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Virtually all alfalfa seed growers are trained, certified and licensed applicators. Training is conducted by university Extension personnel while the certification and licensing is administered by state departments of agriculture. In Oregon new private applicator rules have been adopted which will require all alfalfa seed growers to take continual recertification training to maintain a license.

Table 26 provides potential exposure estimates for oxydemeton-methyl, naled, mevinphos and trichlorfon in the northwest region. Not all alfalfa seed growers elect to apply their own insecticides so the exposure data would only apply to a subset of the grower population. In situations where private applicators are putting on more than one treatment per season, the interval between treatment is generally two or more weeks. The average alfalfa seed acreage managed by Idaho and Oregon growers is much smaller than for producers in Washington or Nevada. Therefore survey data shows less exposure time is required while mixing, loading and spraying fields for Idaho and Oregon seed producers.

Post treatment exposure to the insecticides is negligible. Reentry periods are observed and very little farmer or farm laborer activity occurs in fields prior to harvest.

Acute toxicity data for the four insecticides is summarized in Table 27.

Table 23. Oxydemeton-methyl, naled, mevinphos and trichlorfon use pattern in alfalfa.1/

	% of Acreage Treated	Average treatment rate lb a.i./A	# of Appl. Per Season	Total Lbs a.i. used 1988 season
Idaho and Oregon 1/				
45,000 acres (est. 1988)				
Oxydemeton-methyl	90%	0.375	2.0	30,375
Naled	30%	0.75	2.0	20,250
Mevinphos	10%	0.375	2.5	4,219
Trichlorfon	5%	1.0	1.0	2,250
Washington (Gardena/Touchet Area)				
16,000 acres (est. 1988)				
Oxydemeton-methyl	65%	0.375	1.0	3,900
Naled	30%	1.0	1.5	7,200
Mevinphos	0	0	0	0
Trichlorfon	15%	1.0	1.0	2,400
Washington (Columbia Basin Area)				
10,000 acres est. 1988				
Oxydemeton-methyl	95%	0.375	1.5	5,344
Naled	2%	0.5	1.0	100
Mevinphos	25%	0.375	1.0	938
Trichlorfon	20%	1.0	1.0	2,000
Nevada				
9,500 acres (est. 1988)				
Oxydemeton-methyl	60%	0.4375	1.3	3,242
Naled	25%	0.75	1.0	1,781
Mevinphos	70%	0.375	1.5	3,741
Trichlorfon	1.0%	1.0	1.0	95
Montana				
18,610 acres (est. 1988)				
Dryland and Irrigated				
Oxydemeton-methyl	0	0	0	0
Naled	0	0	0	0
Mevinphos	0	0	0	0
Trichlorfon	19%	1.0	1.0	3,536

1/ NAPIAP Survey, Fall 1988.

Table 24. Summary of oxydemeton-methyl, naled, mevinphos and trichlorfon use in key alfalfa seed states.[1/]

	Lbs a.i. Used in 1988			
State	ODM	Naled	Mevinphos	Trichlorfon
Idaho/Oregon	30,375	20,250	4,219	2,250
Washington				
Gardena/Touchet	3,900	7,200	0	2,400
Columbia Basin	5,344	100	938	2,000
Nevada	3,242	1,781	3,741	95
Montana	Trace	Trace	Trace	3,536
California	Trace	0	Trace	0
Total	42,861	29,331	8,898	10,281

1/ NAPIAP Survey, Fall 1988.

Table 25. Applicator characteristics and application methods for oxydemeton-methyl, naled, mevinphos and trichlorfon in alfalfa.[1/]

State	# of Growers	Av. A of Alf. Seed Per Grower	% Growers Certified Licensed Private Appl.	% of Acres treated by Commercial Aerial Appl.	% of Acres treated by Tractor Pulled Sprayer	% Ground sprayers Pulled by Closed Cab Tractors
ID/OR	700	64	100	40	60	100
WA-G/T	50	320	100	25	75	95
WA-CB	45	222	100	100	0	0
NV	30	317	100	20	80	100

1/ NAPIAP Survey, Fall 1988.

Table 26. Potential exposure estimates for private applicators of oxydemeton-methyl, naled, mevinphos, and trichlorfon in alfalfa.[1/]

State	Hours Per Treatment Spent Mixing/Loading	Applying	# Treatments Per Season	Total Hours Potential Exposure Per Yr.
Oxydemeton-methyl				
ID/OR	0.5 - 1.0	2 - 4	2.0	5 - 10
WA-G/T	2 - 3	5 - 10	1.0	7 - 13
WA-CB	0	0	1.5	0
NV	2 - 3	5 - 10	1.3	9.1 - 16.9
Naled				
ID/OR	0.5 - 1.0	2 - 4	2.0	5 - 10
WA-GT	2 - 3	5 - 10	1.5	10.5 - 19.5
WA-CB	0	0	1.0	0
NV	2 - 3	5 - 10	1.0	7 - 13
Mevinphos				
ID/OR	0.5 - 1.0	2 - 4	2.5	6.25 - 12.5
WA-G/T	2 - 3	5 - 10	0	0
WA-CB	0	0	1.0	0
NV	2 - 3	5 - 10	1.5	10.5 - 19.5
Trichlorfon				
ID/OR	0.5 - 1.0	2 - 4	1.0	2.5 - 5
WA-G/T	2 - 3	5 - 10	1.0	7 - 13
WA-CB	0	0	1.0	0
NV	2 - 3	5 - 10	1.0	7 - 13

[1/] NAPIAP Survey Fall 1988.

Table 27. Acute toxicity data on oxydemeton-methyl, naled mevinphos and trichlorfon.[1/]

Insecticide	Recommended Rate Lbs a.i./A	Chemical Class	Toxicity Class	LD_{50} mg/kg Rat Oral	Rabbit Dermal
Oxydemeton-methyl Metasystox-R	0.375-0.5	OP	II	65-75	350 (rat)
Naled Dibrom	0.5-1.0	OP	II	530	1,100
Mevinphos Phosdrin	0.25-0.5	OP	I	3-12	16-33
Trichlorfon Dylox	0.75-1.0	OP	II	150-400	2100

1/ Farm Chemicals Handbook 1988 and 1988 PNW Insect Control Handbook.

VII. Economic Information, Cost Enterprise Analysis, Insecticide Cost Benefit Estimates.

The cost of oxydemeton-methyl, naled, mevinphos and trichlorfon relative to the benefits realized by the alfalfa seed producer are negligible. Timely control of lygus bugs and secondary pests while conserving essential pollinators increases the per acre yield and value of the commodity 5-10 fold. The practices which include the selective use of this group of insecticides are fundamental to the economic survival of the alfalfa seed enterprise in the northwest. Table 28 provides the current prices for the insecticides and the range of treatment costs per acre. The average cost per application would be $11.32 per acre. In Table 29 this typical treatment cost is compared to other related production inputs. Based on published cost enterprise analysis sheets, the cost of a single treatment represents 1.5-2.5% of the total cost of production. Yet a single lygus bug treatment during the flowering period can increase the per acre value of production nearly $160 (see Table 30). The 1988 average commodity price was $1.25/lb with average yields around 500 lbs/acre. With a gross per acre income of $625 a single insecticide treatment would represent only 1.8% of the value of the commodity.

Potential exposure from private application of these four insecticides is compared to the increase in overall farm income in Table 30. Even in the

unlikely event a grower would apply all four insecticides once per season he would have increased his farm income from $800-$2,000 per hour of application time.

As indicated in Section I, this economic benefit to the alfalfa seed producer is only the first level of benefits. Nearly all the alfalfa seed is sold for replanting of alfalfa hay which supports the nation's dairy, beef, and other animal industries. Pelleted and cubed alfalfa is also a growing export commodity.

Table 28. Typical cost of alfalfa treatments in the Northwest.

Cost Represented in dollars/A

	Cost of Insecticide	Cost of Application	Total
Oxydemeton-methyl	6.50-9.00	4.00-7.50	10.50-16.50
Naled	2.90-6.00	4.00-7.50	6.90-13.50
Mevinphos	2.75-5.50	4.00-7.50	6.75-13.00
Trichlorfon	5.00-7.00	4.00-7.50	9.00-14.50
Range			6.75-16.50
Mean			11.33

Table 29. Cost factors for typical alfalfa seed operation in the Northwest.[1]

$ Per Acre

	Cost of[2] Insecticide Treatment	Total[3] Pesticide Cost	Pollination[4] Cost	Total Cost Per Acre	% of Total Cost Represented by Cost of Single Trt.
Idaho	11.33	108.00	172.50	533.40	2.1
Oregon	11.33	126.00	150.00	774.20	1.5
Washington Gardena-Touchet	11.33	67.72	25.71	602.36	1.9
Nevada	11.33	103.32	75.00	449.26	2.5

1/ Based on cost enterprise budgets published by University of Idaho 1987, Oregon State University 1986, Washington State University 1986 and University of Nevada 1981.

2/ Average NW treatment costs for oxydemeton-methyl, naled, mevinphos, or trichlorfon includes application costs.

3/ Includes all insecticide, acaricide and herbicide costs in typical operation.

4/ Washington 75% alkali bee, 25% leafcutting bee; all other 100% leafcutting bee.

Table 30. Ratio of increase in farm income to potential oxydemeton-methyl, naled, mevinphos, and trichlorfon application exposure in alfalfa.

	No Lygus Control Yield Lbs/A	IPM Lygus[1/] Control Yield Lbs/A	Yield Increase Lbs/A	1988 Price Per Lb	Increase Income Per Acre	Average[2/] Seed Acreage	Total Increase in Farm Income	Worst Case[3/] Scenario of Appli. Exposure Hrs/yr	Increased Income Per/Hr Potential Exposure Time
ID/OR	200	400	200	$1.25	$250	64	$16,000	20	$800/Hr.
WA-G/T	200	400	200	$1.25	$250	320	$80,000	39	$2,051/Hr.
NV	200	400	200	$1.25	$250	317	$79,250	39	$2,032/Hr.

1/ Estimate of yield increase from controlling lygus bugs during pollination-flowering period. Does not include factors of yield increase from controlling secondary insect pests and weeds, pollination and irrigation management.

2/ Total acres alfalfa seed divided by total number of alfalfa growers in production area.

3/ Maximum time to mix, load and spray all four insecticides once per flowering-pollination period. This is extremely unlikely event.

VIII. Survey Methods and Acknowledgements

Data for the assessment of oxydemeton-methyl, naled, mevinphos and trichlorfon uses on alfalfa seed came from a full spectrum of sources. University personnel, seed company representatives, chemical dealer representatives, private consultants and growers all contributed estimates, statistics and observations cogent to the objectives of the report. A standardized survey form was used to collect most of the use data.

Survey data from Idaho, Oregon, Washington and Nevada was collected at special industry meetings held in the production areas during the fall of 1988. Attendance to the meetings by knowledgeable industry leaders resulted in excellent discussion and collection of survey estimates. This process of collecting information directly from the users and recommenders of the insecticide lends special credibility to the data. (See list of attendees, p. 100)

California and Montana, minor users of the four insecticides, submitted data by mail and phone.

Special thanks for technical assistance and resources goes to those listed below.

Technical Resources and Assistance

Oregon

Dr. Clint Shock, Superintendent, Malheur Experiment Station, Oregon State University.

Dr. Bill Stephen, Department of Entomology, Oregon State University.

Idaho

Dr. Craig Baird, Extension Entomologist, S.W. Idaho Research and Extension Center, University of Idaho.

Darrell Bolz, Canyon County Extension Agent, University of Idaho.

Washington

Dr. Carl Johansen, Emeritus, Department of Entomology, Washington State University.

Dr. Dan Mayer, IAREC, Washington State University.

Dr. Walt Gary, Walla Walla County Extension Agent, Washington State University.

Elvin Kulp, Grant County Extension Agent, Washington State University.

Nevada

Dr. Harold Arnett, Emeritus Department of Entomology, University of Nevada.

Gail Munk, Pershing County Extension Agent, University of Nevada.

Gene Wheeler, Humboldt County Extension Agent, University of Nevada.

Montana

Dr. Greg Johnson, Department of Entomology, Montana State University.

California

Vern Marble, Extension Agronomist, University of California, Davis.

Vern Burton, Extension Entomologist, University of California, Davis.

Sharon Mueller, Fresno County Extension, University of California.

Bruce Roberts, Kings County Extension, University of California.

Bob Sailsbery, Glenn County Extension, University of California.

Eric Natwick, Imperial County Extension, University of California.

NAPIAP Alfalfa Seed Survey Participants

Idaho and Oregon Meeting held September 10, 1988, Nampa, Idaho.

University Participants.

Darrell Bolz, University of Idaho Extension Service, Caldwell, Idaho.

Craig Baird, University of Idaho Extension Service, Parma, Idaho.

Ben Simko, Oregon State University Extension Service, Ontarion, Oregon.

Industry Participants

Tom Miles, AgriPro Inc., Nampa, Idaho.

Clarence Ferguson, Vigaro Fertilizer Co., Homedale, Idaho.

Ron Bitner, IPM and Pollination Private Consultant, Caldwell, Idaho.

Lyle Derie, Andrew Seed Co., Ontario, Oregon.

Brent Clark, Clark Seed Co., Ontario, Oregon.

Eino Hendrickson, Whitney Dickenson Seed Growers, Inc., Homedale, Idaho.

Todd Flick, Pioneer Seed, Nampa, Idaho.

Dick Hartley, Union Seed Co., Caldwell, Idaho.

Don Kinkhorst, Allied Seed Co., Nampa, Idaho.

Harold Fannon, Allied Seed Co., Nampa, Idaho.

Brian Finely, Allied Seed Co., Nampa, Idaho.

Dean Sisson, President, Oregon Alfalfa Seed Growers Association, Nyssa, Oregon.

T. K. Stubstad, Mobay, Boise, Idaho.

Washington Gardena-Touchet District Meeting Held September 7, 1988, Touchet, Washington.

University Participants

Walt Gary, Washington State University Extension Service, Walla Walla, Washington.

Ben Simko, Oregon State University Extension Service, Ontario, Oregon.

Industry Participants

Mike Ingham, President Gardena Alfalfa Growers Association, Touchet, Washington.

Dale Peck, Northrup King Co., Touchet, Washington.

Jack McGillis, Arnold Thomas Seed Co., Lowden, Washington.

Art Bussell, grower, Touchet, Washington.

Mark Wagoner, grower, Touchet, Washington.

Henry Garbe, grower, Touchet, Washington.

Washington Columbia Basin District Meeting Held September 7, Moses Lake, Washington.

University Participants

Elvin Kulp, Washington State University Extension Service Ephrata, Washington.

Ben Simko, Oregon State University Extension Service, Ontario, Oregon.

Industry Participants

Richard Stelzer, W L Research, Warden, Washington.

Ed Gordon, grower, Warden, Washington.

Pat McPartland, grower, Warden, Washington.

Jack Nitta, grower, Warden, Washington.

Dale Pomeroy, grower, Warden, Washington.

Ken Goodrich, grower, Moses Lake, Washington.

Tsugio Nakamuna, grower, Warden, Washington.

Lee Seitz, grower, Warden, Washington.

Mike McPartland, President Columbia Basin Alfalfa Seed Growers Association, Warden, Washington.

Dan Roseburg, grower, Moses Lake, Washington.

Nevada Meeting Held August 10, 1988, Winnemucca, Nevada.

University Participants

Duane Flom, University of Nevada Extension.

Gail Munk, University of Nevada Extension.

Gene Wheeler, University of Nevada Extension.

Harold Arnett, University of Nevada, Reno, Nevada.

Ben Simko, Oregon Stage University Extension Service.

Industry Participants

Gene Brinkerhoff, grower, Lovelock, Nevada.

Don Morris, Northrup King Co., Orovada, Nevada.

Robert Monroe, grower, Lovelock, Nevada.

Allen Brinkerhoff, grower, Lovelock, Nevada.

Jim Robertson, Whitney Dickenson Seed Growers Inc., Lovelock, Nevada.

Todd Flick, Pioneer Seed, Nampa, Idaho.

Lloyd Stitt, Private Consultant, Reno, Nevada.

Bob Huizinga, Wilber-Ellis Co., Caldwell, Idaho.

Ricardo Arias, Helena Chemical Co., Lovelock Nevada.

Daniel Hetrick, grower, Orovada, Nevada.

Alan List, grower, Lovelock, Nevada.

Roy Phillips, grower, Lovelock, Nevada.

Ron Bitner, IPM and Pollination Consultant, Caldwell, Idaho.

California - Survey conducted by mail and phone.

University Personnel

Sharon Mueller, University of California Extension Service, Fresno, California.

Bruce Roberts, University of California Extension Service, Hanford, California.

Bob Sailsbery, University of California Extension Service, Orland, California.

Eric Natwick, University of California Extension Service, El Centro, California.

Montana - Survey conducted by mail and phone.

Greg Johson, Montana State University, Bozeman, Montana.

Mae Reynolds, Montana Alfalfa Seed Growers Association, Winnett, Montana.

FIELD CORN

Introduction

There are 67,850,000 acres of field corn grown in the United States (none in Alaska and Hawaii) and Puerto Rico and the Virgin Islands. The largest concentration of corn is in the Midwestern area, with Illinois and Iowa usually alternating between first and second in production. Nationally and for general information, wheat and corn rank first and second in total acreage (1985-1987), respectively. Production in excess of eight billion bushels, however, allows field corn to be the number one valued (nearly 15 billion dollars) field crop (Table 31).

Trichlorofon, formulated as an 80% soluble powder, is presently registered for use on field corn at 0.5 to 1 lb active ingredient per acre per application. This registration is for control of armyworms, primarily fall armyworm, Spodoptera frugiperda (J.E. Smith), and armyworm, Pseudaletia unipuncta (Haworth) and cutworms, primarily black cutworm, Agrotis ipsilon (Hufnagel). There is a maximum use restriction of 3 lb active ingredient per acre per season. But there is no waiting period before harvest.

Table 31. Field crops: Base crop acres, yield, and price, 1985-1987.

Crop	Acres	(1,000 units)	Yield	Units	Crop Value ($1,000)	Price per/unit (dollars)
Alfalfa	25,962,000	87,051	3.35	ton	9,050,541	103.97
Barley	12,420,333	576,305	46.40	bu.	1,020,535	1.77
Corn	67,850,000	8,063,571	118.84	bu.	14,731,030	1.83
Cotton	10,383,467	12,629	1.22	bale	3,564,778	282.27
Oats	15,301,667	426,974	27.90	bu	565,591	1.32
Peanuts	1,539,467	3,803,234	2,470.49	lb.	1,018,050	0.27
Rice	2,415,000	131,998	54.66	cwt.	769,501	5.83
Sorghum	13,748,333	933,088	67.87	bu.	1,574,028	1.69
Soybeans	60,310,000	1,981,115	32.85	bu.	10,069,435	5.08
Sugarbeets	1,208,567	37,845	31.31	ton	831,718	21.98
Sunflowers	2,295,000	2,812,307	1,225.41	lb.	207,889	0.07
Tobacco	623,757	1,300,619	2,085.14	lb.	2,062,230	1.59
Wheat	71,149,000	2,207,313	31.02	bu.	5,929,887	2.69
All crops	285,206,591				51,395,213	

Current Use

Appromimately 5.4 million acres (8%) of the field corn acreage in the United States are annually treated with insecticide to reduce damage caused by the armyworm-cutworm complex. When compared with untreated infested field corn, insecticide treatment of the infested crop is expected to result in 5-10% yield increases (Bergman et al. 1985).

Based on the results of the survey conducted to assess the impact of trichlorfon use on field corn (88.7% response), it has been determined that this compound is recommended by corn specialists for control of the armyworm-cutworm complex in just seven states; California, Kansas, Missouri, Nebraska, Oklahoma, Pennsylvania and Tennessee. A prevalent criticism is that the product is not readily available. Trichlorfon is used on only 7,327 (0.2%) of the 5.4 million corn acres that are annually treated. The amount of trichlorfon and the number of treated acres range from 218 lb on 290 acres (Pennsylvania) to 2,500 lbs on 2500 acres (Nebraska) when compared for six states (Table 32).

Table 32. Location and amount of trichlorfon used in the U.S. (1985-1987).

State	Pounds (AI)	Acres
California	372	324
Missouri	1,020	2,040
Nebraska	2,500	2,500
Oklahoma	1,332	2,110
Pennsylvania	218	290
Tennessee	1,153	1,153
Total	6,595	7,327

Alternative Chemicals

The major alternative insecticides used to control the armyworm-cutworm complex are: carbaryl, chlorpyrifos, fenvalerate, methomyl, methyl-parathion, parathion and permethin. These compounds account for 99.8% of acres that are treated in the United States for armyworms and/or cutworms.

Non-Chemical Contol

The most vulnerable stages of corn growth that are subject to infestation by cutworms and armyworms (except fall armyworm) are the coleoptile stage (just emerged from soil) to the 5-leaf stage (Showers et al. 1983). This insect complex, except for fall armyworm, can be controlled by removing grass and other vegetation by use of tillage operations at least eight days before planting. Early season mowing of grass on conservation terraces will also reduce numbers of armyworms. These operations, if performed within an appropriate time interval before planting, remove food sources of young larvae and subject them to starvation before corn plants become available as food (Showers et al. 1985). Often however, poor weather will prevent the grower from extending the time between tillage and planting. Minimum or reduced tillage systems are not conducive to non-chemical strategies.

Economic Impacts

To Users: Based on responses from the states and territories on trichlorfon use, the production costs, efficacy or corn yield will be unaffected through cancellation of trichlorfon.

Alternative products at similar or at less cost per acre (Table 3) are presently being used on 99.8 percent of acreage being treated for cutworms or armyworms. Responses from two states (Kansas and Oklahoma), indicated, however, that use would increase slightly if trichlorfon was more available to the users.

Consumer/Market: Responses to the "Assessment" survey suggest that the consumer and the market will be unaffected through cancellation of trichlorfon use on field corn.

Limitations of Analysis

Assumption was made that 88.7% (47 of 53 states and territories) response is adequate for verification of the status of trichlorofon use on field corn in the United States.

Table 33. Comparative cost of tricholorfon versus alternative insecticides.*

Common Names	Cost lb a.i.	Rate Used lb a.i./A	Insecticide Cost/A
Carbaryl	3.77	2.0	7.54
Chlorpyrifos	4.25	1.0	4.25
Fenvalerate	39.40	0.1	3.94
Methomyl	16.00	0.45	7.95
Parathion	2.34	0.50	1.17
Permethrin	39.00	0.1	3.90
Trichlorofon	5.60	1.0	5.60

* Application costs of $2-4/Acre (ground) or $3-6/Acre (Air) should be added to insecticide cost/Acre to obtain total costs/Acre.

POPCORN

Current Use

A survey of 50 states and 3 territories requesting the use (1985-1987) of trichlorfon for control of cutworms and armyworms on popcorn was conducted during spring 1989. A large number (47) of responses presented evidence that popcorn is grown commercially only in the mid-section of the United States. Tennessee, Missouri and Kansas north to Ohio, Michigan and Nebraska. Only 7 lb actual ingredient of trichlorfon is used annually in the entire state of Tennessee for insects on popcorn. Based on the results of this survey, trichlorfon is not of importance on popcorn in the United States.

TURF

Pest Damage and Infestation Information

Actual usage data provided by Pesticide Coordinators indicates that trichlorfon is used to control white grubs (including black turfgrass *Ataenius*), cutworms, armyworms, sod webworms, and annual bluegrass weevil. Any of these pests, if not controlled, is capable of causing loss of stand in turfgrass. White grubs attack all species of turfgrass, and are a problem in many parts of the nation. Cutworms, armyworms, and sod webworms are widespread, but are primarily pests on golf course greens. Black turfgrass *Ataenius* is a sporadic problem in the Northeast, but is a greater problem in the Midwest. Annual bluegrass weevil is a moderate to severe pest on annual bluegrass, primarily in parts of New York, New Jersey, Connecticut.

Pest Management Recommendations

Several states provide written recommendations for turf insect control. Apparently all of those states include trichlorfon at least for white grubs and sod webworms. Table 34 provides a list of some of the states and their recommendations. Recommended formulations vary regionally, with the 5G listed more commonly in the Midwest. The 80SP seems to be used in all states where trichlorfon is effective.

Actual Turfgrass Usage Data

a. Percent of commodity treated and area of country involved. The usage of trichlorfon varies widely across the country (Table 35). Trichlorfon is extremely sensitive to high pH, and that limits the chemical's use in areas

such as Texas where much of the soil and irrigation water in many cases are alkaline. In many states, buffering agents are used to counteract alkaline conditions (Table 36).

b. Variability in usage and year-to-year variability: No data available.

c. Frequency of application: The number of treatments applied for a given pest differs from state to state, with most figures not exceeding a maximum of three applications per year. White grubs received 1-2 (mean) (range=1-5) treatments yearly in states that reported usage (Table 37). Webworms were given 0.5-2 (mean) (range=0-3) applications yearly (Table 38). Annual bluegrass weevils received 1 (mean) (range=0-2) treatments annually (Table 39). Fall armyworm treatments (Alabama only) averaged 2 (range=1-3) per 12 month period (Table 40). Cutworms required 0.5-3 (mean) (range=0-5) treatments per annum (Table 41). Black turfgrass _Ataenius_ received 0.5-3 (mean) (range=0-5) a year (Table 42).

The amount of active ingredient applied per treatment varied by state and by pest (Tables 36-41).

Related Crop System Practices

Most turf insecticide applications are made to established turf at least one year after planting. Some golf course turf may be 40 to 60 years old.

Application methods: Based on survey responses, all turf applications are made by ground equipment with hydraulic sprayers (delivering from 100 to 200 gallons of water per acre) for the 80SP or 4EC. The 5G may be applied with drop-spreaders (on some home lawns) or rotary spreaders (golf courses).

[illegible] as where much of the soil and irrigation water is very [illegible]

In many states, wilting agents are used to control [illegible]

[illegible] (Table 36).

[illegible] ly in many [illegible]

[illegible] of [illegible] The number of treatments applied for a given [illegible]

[illegible] from state to state, with most [illegible]

[illegible] applications per year. [illegible] received 1-2 (mean) [illegible]

[illegible] yearly in states that received [illegible] (Table 37)

[illegible] 0.5-2 (mean) (range=0-3) applications yearly Table 39). [illegible]

[illegible] weevils received 1 (mean) (range=0-2) treatments annually (Table [illegible]

[illegible] treatments (Alabama only), averaged [illegible]

[illegible] (Table 40). Cucumbers required 0.5-3 (mean) (range [illegible])

[illegible] per annum (Table 41). Black cutworm, Agrotis [illegible]

[illegible] (range=0-5) a year (Table 42)

[illegible] of active ingredient applied per acre [illegible]

[illegible] Practices

[illegible] applications are made [illegible] as least

[illegible] seeding. Some golf course turf may be 40 to 60 years old.

[illegible] and [illegible] response, all turf applications are

[illegible] hydraulic sprayers (delivering from [illegible])

[illegible] or [illegible]. The [illegible] may be applied with

[illegible] spreader (cell count [illegible]).

Current studies at Penn State by Watschke (personal communication) indicate that pesticide applications to established turf behave very differently than do the same materials when applied to field crops. The turf/thatch environment ties up or otherwise delays many materials so that leaching and surface run-off are reduced tremendously. While Proxol is highly soluble and can penetrate thatch more readily than other turf insecticides, it probably is not as subject to surface run-off or leaching on established turf as it would be in field crop settings. Nevertheless, in the opinion of the Trichlorfon Benefits Assessment Team it should perhaps not be applied within 30 feet of sensitive areas, including wells, ponds, or streams.

The short half life of the material (3 to 10 days under most natural conditions) probably further reduces the likelihood that it will penetrate to and remain in ground-water for a measurable period of time.

Additional points: Trichlorfon tends to be used as a "spot treatment" to clean up grub populations in the fall. This curative approach is an important aspect of integrated pest management, and trichlorfon is uniquely suited to provide the rapid knockdown necessary in such a curative program. The only other turf insecticide which provides a suitable rapid control is isazophos, which by federal label is currently restricted to home lawns, golf course greens, tees, and perimeters of golf courses in about 24 states (state labels).

Trichlorfon appears to have minimal effect on non-target arthropods in New England (Vittum, personal communication). Test plot results indicate it to be less disruptive to beneficial insects than any of the other turf insecticides currently being used.

Potential for Pest Resistance

Based on comments from respondents, there appears to be little or no demonstrated potential for pest resistance in turf settings. (Of 16 respondents who provided information on this question, 14 said, "None observed" or "None." The Alabama respondent mentioned possible resistance in a sod webworm population, and the Pennsylvania respondent noted a drop off in product performance (on grubs) at one golf course where trichlorfon was used annually for five or more years). Presumably, the rapid breakdown of the material minimizes the time any given pest population is subjected to the active ingredient, thereby reducing the likelihood of development of resistance.

On Farm Usage of Alternatives

Percent of commodity treated, and variability. Many alternative turf insecticides are labeled and used in turf pest control (Table 43). Regional use patterns may vary somewhat. Tables 44-48 list the order of preference of chemical alternatives for the control of turfgrass pests in different states. Unfortunately, the three Pacific states provided no information in spite of at least one telephone contact to each, so that western use patterns are uncertain.

The most variable use appears to involve isofenphos, with the percent acres-treated ranging from less than 10% to 85% (Table 49, 50). There does not appear to be a consistent regional pattern in the observed variation.

<u>Frequency of Application</u>

Each alternative has its own pattern for frequency of application, based on its inherent characteristics (Table 49, 50). For example, most respondents reported an average of one application of isofenphos per year and two or more applications with carbaryl. Florida reported a higher frequency of application than did northeastern states, primarily because Florida has a twelve month growing season.

<u>Active Ingredient Applied per Acre</u>

Table 43 lists the labeled rates of application of the listed chemical alternatives for white grubs and for surface feeders (armyworms, cutworms, and sod webworms). There does not appear to be much regional variability in these application rates, based on state recommendations (see Table 49, 50).

Additional points: There has been relatively little research conducted regarding the effects on turf insecticides on non-target organisms. Daniel Potter (University of Kentucky) has published a report on a trial which considered the effect of bendiocarb, chlorpyrifos, isofenphos, and trichlorfon on non-target arthropods. Chlorpyrifos and isofenphos had the greatest effect, reducing some taxa significantly for at least six weeks. According to Potter, "effects of bendiocarb and trichlorfon were generally less severe and more temporary." Unpublished data (Vittum, University of Massachusetts) from a similar study comparing granular and liquid

formulations, diazinon, and isofenphos, granular isazophos, and liquid (SP) trichlorfon generally confirm Potter's findings. Additionally, isazophos appears to be extremely toxic to several families of mites. In any case, trichlorfon compares very favorably to any of the alternatives with regard to effects on both non-target and beneficial arthropods.

Potential for Resistance

To date, there has been no documentation of resistance of white grubs or surface feeders to organophosphate or carbamate materials in turf. Isofenphos does appear to be susceptible to enhanced microbial degradation in certain soils and conditions (normally related to one or more applications to the same sites for three or more years). This degradation results in significantly reduced efficacy, which sometimes is confused with true resistance. In some cases, a soil which is predisposed to microbial degradation of isofenphos seems to be similarly more disposed to enhanced degradation of other active ingredients as well. This "sympathetic" enhanced degradation has not been reported with trichlorfon, but has been reported for some alternatives (carbaryl, isazophos).

Economic and Social Impacts

Methodology and data: Pesticide Coordinators for all 50 states and the District of Columbia were contacted for assistance (Exhibit 1). Those that did not respond within about three weeks were contacted at least once by phone. Results were then summarized.

Quantitative use analysis of trichlorfon: Fifteen states plus the District of Columbia reported some use of trichlorfon (Table 35). Florida and

New Jersey reported treating about 100,000 acres. Only three other states estimated more than 10,000 acres treated with trichlorfon. Many of the reported figures are based on limited verified data.

Impacts of withdrawal of trichlorfon and any alternative: Only New Hampshire, New Jersey, New York, Pennsylvania, and West Virginia reported that cancellation of trichlorfon would have more than mild effect (Table 52). This is apparently due to reliance on trichlorfon for late-season clean-up of white grub problems in those states.

Social impacts: Primary impact of cancellation of trichlorfon would be where it is the preferred material for clean-up of late-season problems with white grubs. This would affect all classes (home lawn, golf course, etc.), of turf in the northeastern states that rely on it for this use. A large portion of such applications are needed because of managerial inaction during the preferred treatment period. Thus, it can be argued that the need for such late-season treatments can be minimized by better management practices. Another major consideration is that trichlorfon is among the safer materials available in terms of human health or environmental considerations. In some areas of the country, it is apparently the preferred material for use in school yards (although there is some question as to how many school yards even require treatment). Loss of trichlorfon could result in instances of greater human exposure to toxicity from alternatives. Almost all alternatives are more damaging to populations of beneficial arthropods. There are not sufficient data

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to provide adequate evaluation of the environmental impact and greater losses of beneficial arthropods. Those losses could, however, cause some reduction in turf quality or lead to additional insecticide applications due to outbreaks of secondary pests.

Economic impact: In those areas where severe grub damage occurs in the late season (or where skunks or raccoons destroy grub infested turf areas), turf renovation can be very costly. An economic analysis can be based on the cost of replacing the area with sod ($1.50 to $3.00 per square yard) or based on total renovation, beginning with sod preparation and including seeding and establishment. The total cost of renovation would depend on whether the area were to be treated with glyphosate, followed by slicing or even a total removal of old sod. The cost of seed will generally range from $8 to $10 per 1,000 square feet.

A well established lawn is generally regarded as increasing the value of a home by 2 to 5%. In a metropolitan area such as Boston, where the median cost of a single family home is $220,000, this would translate to a value of $4,400 to $11,000.

Exposure Assessment

Apparently the newly revised label for trichlorfon will have a "Danger/ Poison" signal word because of hazards to eyes during handling. While this eye hazard is documented in mammalian toxicity tests, there have been no reported exposure problems during application. New packaging with safety in mind should further reduce any handling hazard.

The "proposed" change in the signal word on the label will undoubtedly change use patterns, at least in certain areas of the country. Many municipal and athletic field managers may be forced to look for less restricted materials.

Water Contamination Potential

Trichlorfon is highly soluble compared to other turf insecticides and it penetrates thatchy conditions more readily than the alternatives. It also has a much shorter half life than the alternatives (3 to 10 days versus 2 to 10 weeks under normal conditions). As a result, it presumably breaks down in most cases before it gets to ground water. The Team is unaware that trichlorfon has been detected in any of the ground water test wells sampled by EPA over the past several years. Nevertheless, it would be prudent to avoid using the material immediately adjacent (for example, perhaps within 30 feet) to open water or well heads.

Conclusions and Recommendations

Turfgrass: Trichlorfon fills a limited but significant need in turf pest management. Its sensitivity to alkaline pH limits its use in some parts of the country, and there are no pests against which it is uniquely efficacious. However, it is less hazardous to man and the environment than most of the alternatives. It is also the treatment of choice in the Northeast for established infestations of white grubs, due to its fast action. For these reasons, the assessment team recommends continued registration.

Table 34. Recommended treatment rates for selected pests in 11 states (from Agricultural Extension Service publications).

	Treated Pest*						
State	AW	BTA	CW	FAW	GRUBS	SWW	Formulation
New Hampshire					8	8	80SP, 4EC
New York			8		8	8	not specified
Michigan			4-6		8	4-6	not specified
North Carolina	3.5-7			3.5-7	8	3.5-7	80SP
Ohio	3-8	8	6-8		8	3-8	80SP, 4EC
Pennsylvania	+		+		+	+	no rates or formulation specified
Virginia		8	6-8		8	6-8	not specified
Illinois	4	8	4		8	4	80SP, 5G
Alabama			4-8	1	6-8		80SP
South Carolina				6-8	8	6-8	80SP, LS
Florida					8	3.2-8	not specified

*all figures at 1.0 lb a.i./A
AW = armyworm
BTA = black turfgrass ataenius
CW = cutworm
FAW = fall armyworm
SWW = sod webworm

Table 35. Estimates of acres of turfgrass, use of trichlorfon on turfgrass, and total cost per acre of treatment in states that responded to requests for data.

STATE	TOTAL ACRES	ACRES TREATED	$$ PER ACRE	$$TOTAL COST
AK	-	0	-	
AL	600,000	18,000	6-10	108,000-180,000
AR	1,500,000	30,000	3-5	90,000-150,000
AZ	120,000	6,000	-	est. 30,000
CO	-	-	-	
FL	2,100,000	105,000	36	3,780,000
GA	720,000	< 7,200	25-60	180,000-432,000
IA	2,000,000	2,500	UNK	est. 12,500
IL	917,000	5,000	50	250,000
ID	-	0	-	
LA	500,000	< 5,000	11	55,000
MA	300,000?	-	60-80	
MD	969,514	20,000		
ME	-	0	-	
MO	> 600,000	-	UNK	
MS	881,191	-	-	
NC	> 2,000,000	< 500	80	40,000
NH	UNK	115	100	11,500
NJ	865,000	100,000	100	10,000,000
NY	?	?	-	
NV	5,000	> 10		
OH	1,936,851	NA	UNK	
OK	153,853	9,231	40	369,240
PA	> 1,000,000	NA	100	
RI	8,000 commonly	?	-	
TN	47,000 commonly	23,500	3	69,600
TX	3,200,000	< 500	-	
WV	30,000	6,000	-	
WY	UNK	0	NA	
National Totals	20,453,409	338,556		11,119,620 - 15,129,840

Table 36. Use of buffering agents with trichlorfon.

States	% Using	Effects Beneficial	Effects [1/] Not Beneficial
AL	10	yes	
AR	30	yes	
AZ			
FL	50	yes	
GA	0		
IL	5	yes	
MA	25	yes	
MD	40	yes	
MO	UNK		
NC	UNK		
NH	< 10	UNK	
NJ	0		
NY	?		
NV	0		
OH	UNK		
OK	88	yes	
PA	5	variable	
RI	30	yes	
TN			
WV	5	yes	

1/ No adverse effects reported.

Table 37. Usage of trichlorfon for control of white grubs in turfgrass.

State	Formulation 80SP	5G	% Control	No. Applications/Acre Min.	Avg.	Max.	Rate (lb a.i./A)
AL	90	10	75	1	1	2	6-10
AR	50	50	85	1	2	3	8
AZ	0	100	70	1	1	1	8
CO	-	-	70	-	-	-	-
FL	100		70	1	2	3	6
GA	-	-	-	-	-	-	10
IA	100	0	45	0	1	2	8
IL	80	20	70		1		8
LA	minor		good	-	1	-	-
MA	90	10	60-90	1	1	2	8
MO	75	25	NA		1		6.8-10.2
MD	-	-	60-90	1	1	2	8
MS	100					3	10
NC			85	1	1.5	2	8
NH	95	5	90-95	1	1	2	8
NJ	75	25	87	1	1	2	8
NY	70	30	40-95	1	2	?	8
OH			82	1	1	1	8
OK	99	1	85	-	-	-	8
PA	75	25	73	1	1	2	8
RI	90	10	80-90	1	1	2	8
TN			85	1	2	5	6
TX	0	0	0	-	-	-	8
WV	75	25	85-95	1	0	2	8

Table 38. Usage of trichlorfon for control of webworms in turfgrass.

State	Formulation 80SP	5G	% Control	No. Applications/Acre Min.	Avg.	Max.	Rate (lb a.i./A)
AL	100	0	75	1	2	3	4
AZ	-	-	90	-	-	-	8
FL	100	0	70	1	2	3	6
GA	-	-	-	-	-	-	4
IA	100	0	UNK	0	1	2	8
IL	-	-	-	-	-	-	4
MA	95	5	NA	1	1	2	8
MO	75	25	NA		1		6.8-10.2
NC	-	-	90	2	2	3	6
NY	70	30	?	0	1	?	8
OH			90	1	1	1	6
OK	99	1	95	-	-	-	6-8
PA	60	40	NA	1	1	2	-
RI	-	-	80-90	1	1	2	-
TN	-	-	85	1	0.5	1	4
WV	100	0	95-100	1	-	2	5-8

Table 39. Usage of trichlorfon for control of annual bluegrass weevil (*Hyperodes* weevil) in turfgrass.

State	Formulation 80SP	5G	% Control	No. Applications/Acre Min.	Avg.	Max.	Rate (lb a.i./A)
MA	100	0	70-80	1	1	2	8
NY	70	30	?	0	1	?	8
PA	NOT USED						
RI	NOT USED						

Table 40. Usage of trichlorfon for control of fall armyworm in turfgrass.

State	Formulation 80SP	5G	% Control	No. Applications/Acre Min.	Avg.	Max.	Rate (lb a.i./A)
AL	100		75	1	2	3	4-6

Table 41. Usage of trichlorfon for control of cutworms of turfgrass.

State	Formulation 80SP	5G	% Control	No. Applications/Acre Min.	Avg.	Max.	Rate (lb a.i./A)
AL	100	0	75	1	2	3	4
AR	50	50	85	1	2	3	8
AZ	-	-	90	-	-	-	-
GA	-	-	-	-	-	-	4
IA	100	0	UNK	0	1	2	4.4
IL	100	0	90	-	2	-	4
MD	-	-	70	2	2	4	8
MO	75	25	NA	-	1	-	6.8-10.2
NC	-	-	95	2	2	2	6
NY	70	30	?	0	1	?	8
OH	-	-	90	2	2	3	6
OK	99	1	92	-	-	-	6-8
PA	90	10	NA	1	3	5	-
RI	-	-	80-90	1	1	2	-
TN	-	-	80	1	0.5	1	4
WV	100	0	95-100	2	-	4	5-8

Table 42. Usage of trichlorfon for control of black turfgrass Ataenius in turfgrass.

State	Formulation 80SP	5G	% Control	No. Applications/Acre Min.	Avg.	Max.	Rate (lb a.i./A)
IA	100	0	UNK	0	1	2	8
MA	90	10	80	1	1	2	8
NJ	100	0	75	1	1	1	8
NY	70	30	?	0	1	?	8
OH	-	-	85	1	1	2	8
PA	90	10	NA	1	3	5	-
RI	NOT USED						
TN	-	-	85	1	0.5	1	4
WV	100	-	-	1	-	2	8

Table 43. Pesticides actually used as alternatives to trichlorfon for control of turfgrass pests.

	lb a.i. per acre	
	WHITE GRUBS	SURFACE FEEDERS
bendiocarb	2-4	2-4
carbaryl	8	4-8
chlorpyrifos	(2)	1-2
diazinon	4	2-4
ethoprop	5	-
isazophos	2	1-2
isofenphos	2	1-2

Table 44. Order of preference among alternatives to trichlorfon for control of white grubs in turfgrass.

STATE	1st	2nd	3rd
AL	bendiocarb (comm) diazinon (home)	ethoprop	isazophos
AR	diazinon	isofenphos	bendiocarb
AZ	isofenphos	bendiocarb	isazophos
CO	-	-	-
FL	isofenphos	carbaryl SL	bendiocarb
GA	isofenphos	acephate	
IA	isazophos	bendiocarb	ethoprop
IL	bendiocarb	isofenphos	diazinon
MA	bendiocarb	ethoprop	isofenphos
MD	isazophos	isofenphos/ethoprop	bendiocarb
MO	isazophos	diazinon	ethoprop
MS	chlorpyrifos		
NC	isazophos	isofenphos	diazinon
NH	isofenphos	isazophos	bendiocarb
NJ	bendiocarb	ethoprop	isazophos
NY	bendiocarb	carbaryl	ethoprop
NV	isofenphos	carbaryl	diazinon
OH	isazophos	ethoprop	bendiocarb
OK	carbaryl SLR	chlorpyrifos	isazophos
PA	bendiocarb isazophos	ethoprop	carbaryl
RI	bendiocarb	isofenphos	diazinon/isazophos
TN	diazinon	isazophos	isofenphos
WV	isazophos	isofenphos	bendiocarb

Table 45. Order of preference among alternatives to trichlorfon for control of webworms in turfgrass.

STATE	1st	2nd	3rd
AL	diazinon	acephate	chlorpyrifos
AZ	isofenphos	bendiocarb	isazophos
FL	chlorpyrifos	acephate	carbaryl (SL)
GA	acephate	chlorpyrifos	carbaryl
IA	chlorpyrifos	bendiocarb	ethoprop
IL	diazinon	carabaryl	chlorpyrifos
MD	chlorpyrifos	isofenphos	bendiocarb
MA*	chlorpyrifos	carbaryl	bendiocarb
MO	isazophos	ethoprop	bendiocarb
NC	isazophos	isofenphos	chlorpyrifos
NH	chlorpyrifos	isazophos	bendiocarb
NY	chlorpyrifos	bendiocarb	carbaryl
NV	carbaryl	diazinon	chlorpyrifos
OH	chlorpyrifos	diazinon	carbaryl
OK	chlorpyrifos	bendiocarb	carbaryl SLR
PA	chlorpyrifos	isazophos	carbaryl
RI	chlorpyrifos	diazinon	carbaryl
TN	diazinon	chlorpyrifos	carbaryl
WV	chlorpyrifos	isazophos	bendiocarb

Table 46. Order of preference among alternatives to trichlorfon for control of cutworms in turfgrass.

STATE	1st	2nd	3rd
AL	chlorpyrifos	carbaryl	acephate
AR	-	-	-
AZ	chlorpyrifos	-	-
IA	carbaryl	isazophos	chlorpyrifos
IL	chlorpyrifos	diazinon	carbaryl
GA	acephate	chlorpyrifos	carbaryl
MA	chlorpyrifos	carbaryl	bendiocarb
MD	chlorpyrifos	isazophos	bendiocarb/ethoprop
MO	carbaryl		
NC	chlorpyrifos	carbaryl	diazinon
NH	chlorpyrifos	isazophos	fluvalinate
NY	chlorpyrifos	bendiocarb	carbaryl
NV	carbaryl	diazinon	chlorpyrifos
OH	carbaryl	acephate	chlorpyrifos
OK	chlorpyrifos	bendiocarb	carbaryl SLR
PA	chlorpyrifos	carbaryl	isofenphos
RI	chlorpyrifos	diazinon	carbaryl
TN	diazinon	chlorpyrifos	carbaryl
WV	isazophos	chlorpyrifos	carbaryl

Table 47. Order of preference among alternatives to trichlorfon for control of black turfgrass _Ataenius_ in turfgrass.

STATE	1st	2nd	3rd
AR	diazinon	isofenphos	bendiocarb
IA	isazophos	bendiocarb	isofenphos
IL	bendiocarb	diazinon	isofenphos
MA	isazophos	isofenphos	bendiocarb
NH	isofenphos	isazophos	bendiocarb
NJ	bendiocarb	ethoprop	
NY	bendiocarb	carbaryl	ethoprop
OH*	bendiocarb	ethoprop	isofenphos
PA	bendiocarb	ethoprop	isofenphos
RI	chlorpyrifos	diazinon	carbaryl
WV	isazophos	isofenphos	bendiocarb

Table 48. Order of preference among alternatives to trichlorfon for control of annual bluegrass weevil (_Hyperodes_ weevil) in turfgrass.

STATE	1st	2nd	3rd
MA	isazophos	chlorpyrifos	
NH	chlorpyrifos	isazophos	bendiocarb
NY	chlorpyrifos	bendiocarb	carbaryl
PA	isazophos	chlorpyrifos	isofenphos
RI	chlorpyrifos	diazinon	carbaryl

Table 49. Usage of alternatives to trichlorfon for control of white grubs in turfgrass.

State	Alternative	% acres treated	No. treatments Min.	Avg.	Max.	Cost/acre treated ($)	% Control
AL	diazinon	25	1	2	3	65	80
	bendiocarb	8	1	1	2	100	85-90
	isofenphos	10	1	1	2	85	70
	isazophos	5	1	1	1	100	> 90
	carbaryl	15	1	2	3	70	70
	ethoprop	10	1	1	1	100	85-90
AR	diazinon	45	1	2	3	NA	75-80
AZ	isofenphos	85	1	1.5			> 85
CO	-	-	-	-	-	-	-
FL	isofenphos	50	1	2	3	30	80
	carbaryl (SL)	30	1	2	3	32	70
	bendiocarb	10	1	2	3	NA	60
GA	isofenphos		1	1	2	75	75
IL	diazinon	30		1		45	70
	bendiocarb	30		1		45	
	isofenphos	30		1		45	
MA	Bacillus popilliae	< 5	1	1	-	> 150	20-80
	entomog. nematodes	< 5	1	1	2	100-500	15-95
	isazophos	< 10	1	1	2	70	85-100
	bendiocarb	30	1	1	2	110	85-95
	isofenphos	20	1	1	1	80	70-90
NH	isofenphos	< 10		1			
	bendiocarb	< 5		1			> 90
	isazophos	NA		1			> 90
MD	Bacillus popillie	< 2	1	1		150	40-80
	isofenphos	8	1	1		60	80
	isazophos	< 2	1	1		60	90
	diazinon	8 1	1	1		40	80
NC	isazophos	30	1	1	2	85	97
	isofenphos	40	1	1	2	80	95
	diazinon	30	1	1	2	65	90

Table 49. Usage of alternatives to trichlorfon for control of white grubs in turfgrass.--continued

State	Alternative	% acres treated	No. treatments Min.	Avg.	Max.	Cost/acre treated ($)	% Control
OK	chlorpyrifos	2	1	2	3	12	80
	carbaryl SLR	2	1	2	3	50	85
	isofenphos	1.3	1	1	2	140	89
	bendiocarb	1.3	1	1	2	65	78
	isazophos	1.3	1	1	2	90	92
TX	diazinon	30	0	1	2	-	75-90
	chlorpyrifos	5	0	1	2	-	40-70
	isofenphos	5	0	1	2	-	40-80
	carbaryl	2	0	1	2	-	75-85
WV	isofenphos	40	1	1	2		85-95
	isazophos	40	1	1	2		90-100

Table 50. Usage of alternatives to trichlorfon for control of surface-dwelling pests (cutworms, armyworms, sod webworm) in turfgrass.

State	Alternative	% acres treated	No. treatments Min.	Avg.	Max.	Cost/acre treated ($)	% Control
AL	diazinon	25	1	2	3	65	80
	chlorpyrifos	40	1	2	3	70	> 90
	carbaryl	15	1	2	3	70	70
	acephate	20	1	2	3	45	75-90
AR	diazinon	45	1	2	3	NA	75-80
	bendiocarb	10	1	2	3	NA	75-80
FL	chlorpyrifos	50	1	2	3	25	80
	acephate	30	1	2	3	31	70
	carbaryl	10	1	2	3	32	60
GA	acephate	50	1			15-30	90
	carbaryl	50	1			20-25	90
IL	chlorpyrifos	90		4		45	90
MA	carbaryl	NA	1	1	2	NA	80-90
	bendiocarb		1	1	2		85-95
	diazinon		1	1	2		75-90
MD	chlorpyrifos	5		1		40	90
	diazinon	2		1		40	90
NH	chlorpyrifos	5	1	2	4		> 90
	isazophos	NA					> 90
NC	chlorpyrifos	60	2	2	2	55	95
	carbaryl	30	2	2	2	20	90
	diazinon	10	2	2	2	65	95
OK	chlorpyrifos	2	1	2	3	12	80
	carbaryl	2	1	2	3	50	85
TN	diazinon	1	1	1	2		85
WV	chlorpyrifos	20	2		4		90-100

Table 51. Response of 50 states and District of Columbia to request for trichlorfon data.

NOT RESPONDING: CA, CT, DC, DE, IN, HI, KY, MN, ND, NE, NM, MI, MT, OR, SD, UT, VA, VT, WA, WI

RESPONDING, BUT NO DATA: KS

RESPONDING, NO USE, AND NO OTHER INFORMATION: AK, ID, ME, WY

RESPONDING WITH DATA: AL, AZ, AR, FL, GA, IA, IL, LA, MA, MD, MO, MS, NC, NH, NJ, NY, NV, OH, OK, PA, RI, TN, TX, WV

Table 52. Estimated impact of cancellation of trichlorfon for use in turfgrass.

STATE	ROOT FEEDERS			SURFACE		
	none	mild	severe	none	mild	severe
AL		x			x	
AR		x			x	
AZ		x			x	
FL		x			x	
GA		x			x	
IA		x		x		
IL		x		x		
LA	x			x		
MA		x		x		
MD		x			x	
MO		x			x	
MS						
NC	x			x		
NH			x		x	
NJ			x	x		
NY			x		x	
NV	x			x		
OK		x			x	
OH			x		x	
PA			x			x
RI		x			x	
TN		x			x	
TX	x			x		
WV			x		x	

Exhibit 1.

Miscellaneous Responses on Selected Subjects from Individual States

A. Resistance to trichlorfon

AL - possible sod webworm
AR - none observed
AZ - none
FL - none observed
GA - none observed
IA - none reports
IL - none
MA - none observed
MD - none to date
MO - unknown
NC - none known
NH - none observed
NJ - none observed
NY - none observed
OH - none seen
OK - none
PA - "I have observed a reduction (weakening effect) in product performance where trichlorfon has been applied annually for ca. 5 years at one golf course".
RI - none
WV - none

B. Restrictions/environmental difficulties

AL - unknown
AR - none
AZ - none
FL - safe
GA - safe
OH - know of none
LA - safe
MA - groundwater (because of solubility) but probably overstated (because of very short half life)
MD - none to date
MO - high solubility allows leaching
NC - none known
NH - very water soluble, potential leaching
NJ - some phytotoxicity reported
NY - none
OH - know of none
OK - none
PA - a change in product label signal word from Warning to Danger/Poison may have an impact on product use
RI - leaching
WV - none

C. Impact of trichlorfon on beneficials

Al - unknown
AR - mild impacts to earthworms
AZ - little, not much (which is good)
FL - no more than alternatives
GA - kills them
IA - moderate but relatively unimportant
IL - slight
LA - small
MA - minimal (short residual); field tests confirm short-lived, if any, effects
MD - just as bad as any others
MO - no data
NC - less than alternatives
NH - none observed
NJ - none observed
NY - short residual lessens impact and hastens reintroduction of beneficials
OH - very short term
OK - no effect known
PA - NA (construed to mean of no consequence)
WV - no major

D. Other comments

AL - Turf insecticides are few in number. Trichlorfon "fits a niche" for late season cleanup of grubs that is unlike the role of alternative insecticides. Only isazophos - a more toxic, costly, and limited use insecticide - is as effective for late season grub treatments. Trichlorfon fits as an alternative for rotation of insecticides for late season grub control.

CO - There is essentially no use at present in the state of Colorado. I (Whitney Cranshaw, Extension Entomologist) have tested it against white grubs, the key target pests in Colorado, and it appeared to give approximately 70% control. This is in line with the alternative products (Diazinon, Sevin, and Dursban) with which it competes. Although trichlorfon has some potential advantages in water solubility and minimal impact on predators, the high pH conditions present often break it down too rapidly. As far as I can tell there would be essentially no impact from trichlorfon cancellation.

FL - Alternatives are as effective and economical; manufacturer hasn't done much to promote product.

GA - Very little trichlorfon is used, except in late season grub control.

LA - Good in a rotational program for caterpillars and grubs in fall.

MD - The low cost is the main reason for its use in Maryland.

NC - Cancellation would have little impact.

NH - The loss of Dylox is most serious for grub control on school grounds. Groundskeepers prefer to use a non-restricted material that has low toxicity and does not require much in protective clothing. Schools are under more pressure from the public not to use any pesticides.

NJ - Oftanol has not been dependable during past two years. Thus, Oftanol does not qualify as suitable alternative for DYLOX/PROXOL.

NV - We have few insect pest problems in turf. No commercial use that I could identify. When insecticides are used, it is generally diazinon.

OH - Dylox/Proxol is a much needed, broad spectrum, short residual material. We MUST preserve it FOR USE ON TURF.

WV - Need to keep as an available choice for turfgrass managers because it is least expensive for parks and homeowners; also as an alternative to Oftanol which may have problems.

LIVESTOCK

CURRENT USE

There are two uses of Neguvon (trichlorfon) for livestock. These are for grubs and lice. Neguvon is also used as an oral treatment in horses for horse bot control, but is regulated by FDA. However, if the use of Neguvon is not continued for ectoparasites, it is not likely that the usage of Neguvon for horse bot control would be of sufficient magnitude to continue production for this minor use.

Neguvon is registered and sold as a 8% concentrate and is diluted with water and applied at the rate of 1/2 fluid ounce per hundred pounds of body weight. One application will control cattle grubs and lice.

PERFORMANCE AND ALTERNATIVE INSECTICIDES

Grubs in beef and non-lactating dairy cattle can be controlled effectively with systematic insecticides, if they are used properly. The insecticides may be applied as food additives, sprays, dips, or pour-ons. Regardless of how they are applied, they are absorbed into the animal's body or circulatory system, distributed to all parts of the body, and then eliminated from the body after a relatively short period of time. Because of the short duration in the body, the pour-on, spray, or dip treatments should be withheld until soon after the fly season is over. If these treatments are delayed too long after the fly season, the grubs may have reached the spinal column or gullet in large numbers and killing the grubs at this time could result in detrimental effects on the animal. Toxins released from killed grubs in the esophagus may cause esophageal edema--an inability by the animal to feed or take water, and dead grubs in the spinal column may result in temporary paralysis of the hind quarters.

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paralysis of the hind quarters.

Table 53. Alternate insecticides that can be used for cattle grub and/or lice control.

Pour-Ons 1/	Cost/100 lb body weight
Tiguvon 3% OS	$0.06
Warbex 13.2%	0.09
Spotton (Fenthion) 20%	0.07
Injectable 2/ 3/	
Ivomec	$0.49
Spray 2/	
Co-Ral 25 WP	0.08
Co-Ral 11.5% EC	0.08

Table 54. Alternate insecticides that are used for lice control only.

Sprays 2/		Cost/100 lb body weight
Atroban	11% EC	$0.05
Ectrin	10% WDL	0.06
Ectiban	5.7% EC	0.05
Malathion	57% EC or 25% WP	0.01
Methoxychlor	25% EC or 50% WP	0.02
Rabon	50% WP	0.02
RaVap	28.7 WP	0.03
Pour-Ons 1/		
Dursban	44 (43.2% OS)	0.09
Lysoff	7.6 E (Fenthion)	0.04
Delice	1.% (permethrin)	0.07

1/ Prices from Johnston 1989.

2/ Prices from wholesale store, Lexington, Kentucky.

3/ Ivomec will not control biting lice. New pour-on Ivomec, not yet approved, will kill both sucking and biting lice.

The most important alternatives as identified by livestock (veterinary) entomologists beginning with the most important are: Ivomec (ivermectrin), Warbex (famphur), Tiguvon (fenthion), and Spotton (also Tiguvon) with sprays being used less than any of the products due to inconvenience and costly applicating equipment [poll of livestock Entomologist at the 33rd Annual Livestock Insect Workshop Conference, Lincoln, Nebraska, July 1989]. There have been numerous reports of non-target bird kills with Warbex [Loomis, 1986, Felton, et al., 1981, Henney, et al., 1985, Franson, et al., 1985] and Fenthion [Hanson and Howell, 1981].

Economics of Livestock Pests Controlled With Trichlorfon

All of the above alternatives are presently available. The amount of Neguvon sold each year will treat approximately 22.5 million head of 200 lb. animals at a cost of 2.5 million dollars. The use of alternates for the control of grubs and/or lice would range from $2.7 million to $11 million. If only lice were to be controlled the cost would be approximately $0.5 million to $4 million depending whether a spray or a pour-on treatment is administered. Usually, sprays require at least two treatments and the costs of labor and equipment need to be considered. The proportion of increased cost would be the same if the least number of cattle grubs are caused in several ways. Gadding of young stock in spring results in lower weight gains, and infestations in older stock also reduce beef weight gains and dairy production. At slaughter, meat surrounding grubs (locked beef or jellied beef) must be trimmed away and discarded (Knapp, 1961, Broce 1985, Wright, 1985). Besides the actual loss of meat, the carcass is downgraded and brings a lower price. The usefulness of grub-perforated hides is reduced and their sale value is also greatly reduced.

During 1964, the average trim loss on heavily infested carcasses ranged from 5 to 7 dollars per carcass, or about 2 to 3 cents per pound (Rich, 1970). The national losses on income to beef and dairy producers due to the combined effects of grubs is estimated at 607.8 million dollars annually (Drummond, 1987).

A few grubs embedded in the back will cause little damage and they can be controlled by squeezing the grubs out of the cysts. At present, this is the only control method that can be used on lactating dairy cows. There are no practical or effective controls against the egg, pupa or adult stages.

Control of lice should begin in the fall before the infestation gets large and the animals look scruffy. If nits (eggs) are visible on an animal, a loss may have already occurred. Insecticides to control lice may be applied as sprays, dips, dusts, as pour-ons, or as self-treatments such as dust bags or backrubbers. When cattle are dipped for cattle grub control, they may also remain free of lice for the winter unless untreated cattle are introduced into the herd. Insecticides registered for use on beef may not be permissible for use on dairy cows. Some insecticides and treatments such as oilers or dusters only aid in the suppression of lice as a secondary feature of some other treatment, thus a different insecticide may be warranted if lice are the only problem.

Animals that are heavily infested with lice may be weakened by blood loss and become more susceptible to diseases. Young calves may be killed as a result of heavy infestations. Blood loss and irritation prevent beef from making maximum weight gains, and heavy lice infestations will reduce the milk production of dairy cattle by 10 percent or more. Drummond (1987) has estimated 126.3 million dollars lost annually due to lice.

Use Data

Sales data (Cox, 1989) give the gallons of 8% Neguvon produced for cattle grub and lice control as follows:

1986[1]	1987[1]	1988[1]
184,700 gal.	192,000 gal.	149,000 gal.

[1]Produced by all companies selling Neguvon in the U.S.

The average price is $14.24/head of cattle. One gallon of the concentrate will treat the following numbers of cattle with respect to body weight:

Table 55. The number of cattle and the cost per treatment as a function of body weight.

Weight of animals (pounds)	200	300	400	500	600	700	800	900	1000
Number treated	128	85	64	56	42	36	32	28	25
Cost/hd.	$0.11	0.17	0.22	0.28	0.34	0.40	0.45	0.51	0.57

Cost relative to body weight is approximately $0.056/cwt.

Less Neguvon was produced in 1988 than in previous years due to the increased use of Ivermectrin. However, if we assume that the number of average gallons of Neguvon produced for those three years (175,233 gallons) were sold and used for grub and for lice control, the number of cattle treated per year and the cost/hd. would be as follows:

Table 56. Number of animals that may be treated annually as a function of Neguvon production and animal body weight.[1]

Weight of Animals (lbs)	Treated with 175,233 Gallons	Cost of Treatment
200	22,429,824	$2,467,281
300	14,894,805	2,532,117
400	11,214,912	2,467,281
500	8,936,883	2,412,958
600	7,359,786	2,502,327
700	6,308,388	2,523,355
800	5,607,456	2,523,355
900	4,906.524	2,502,327
1,000	4,380,825	2,497,070

[1]Beef and non-lactating dairy animals.

APPENDIX

LIVESTOCK INSECTS CONTROLLED WITH NEGUVON (TRICHLORFON)

CATTLE GRUBS

Two similar species of cattle grubs occur in the U.S.--the common cattle grub or heel fly, *Hypoderma lineatum*, and the northern cattle grub or bomb fly, *Hypoderma bovis*. The habits of both flies are similar, although with some variations. They usually attack only cattle, but, occasionally, horses pastured near cattle may be attacked.

The adult flies resemble honeybees in size and appearance, but they are rarely seen, even though they may be present from the first warm days of spring to mid-July. They are more prevalent during late May through June. These pests are unable to bite or sting, but cattle instinctively fear them. Cattle will run high-tailed from the flies, especially the bomb fly, or they may stand in water to avoid having the flies lay eggs on them. Eggs are usually laid on the heels of the animal, but egg deposition may also occur on the flanks or belly if the animal is lying down. The grubs that hatch from the eggs bore through the skin and begin several months of migration through the animal's body. The heel fly grubs usually migrate to the gullet and the bomb fly grubs to the spinal canal, and from these places they migrate to the animal's back. After reaching the back, each grub cuts a small hole in the hide which serves as a breathing port and escape hatch. The presence of the grubs in the animal's back causes the formation of cysts which continue to enlarge over a two-month period. The first cysts are large enough by late December to be felt by rubbing one's hand over the animal's back. When the grubs are fully developed, during late winter

or early spring, they squeeze out through the cyst holes, fall to the ground and pupate. The adult flies emerge during the first warm days of spring, mate and are ready to lay fertile eggs immediately.

LICE

There are two main groups, or orders, of lice--Mallophaga (chewing lice) and Anoplura (sucking lice). Both kinds are small, wingless, flattened, external parasites that are rather "host specific". The Anoplura attack only mammals, whereas the Mallophaga attack mainly birds and a few mammals. Besides the difference in mouthparts, as noted, the Anoplura also differ in appearance from Mallophaga feed mainly on hair, skin excretions, and scabs. Both kinds of lice have a gradual metamorphosis--egg, nymph and adult stages in their life cycles.

From a practical viewpoint it is convenient to group species of lice according to their host. For instance, cattle lice are normally considered as a group, although both Mallophaga and Anoplura may be present.

CATTLE LICE

Of the lice that may infest domestic animals, cattle lice are the most economically important. Three species of sucking lice: the long-nosed cattle louse, *Lignognathus vituli*, the short-nosed cattle louse, *Haematopinus eurysternus*, the cattle tail louse, *H. quadripertusus*, and the little blue louse, *Solenoptes capillatus*, and one chewing louse, the cattle chewing or little red louse, *Bovicola bovis*, are the most common.

Infestations by any of these lice are light in summer and early fall with only a few cattle in a herd harboring lice. Usually those cows with oily skin

are free of lice at this time. As the animal's hair gets heavier for winter, the lice begin to increase and spread from cow to cow. Sucking lice infestations usually show up first on areas of the body not easily scratched by the animal, such as the sides of the neck, the brisket, the inner surface of the thighs and on the head around the nose, eyes and ears. Biting lice first show up on the withers and base of the tail where they congregate in colonies. A lice colony may produce a scab the size of a quarter or even 4 or 5 inches across. Under the scab, hundreds of lice may be found feeding on raw tissue. Both kinds of lice may infest all areas of the body when infestations are bad. If left unchecked, the lice will reach their peak abundance in late winter and early spring. The lice population drops sharply when the animals shed their winter coat of hair. For reasons that are not completely understood, individual cows may continue to harbor damaging numbers of lice.

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General Appraisal of Economic and Social Benefits of Trichlorfon Use on Selected Crops and livestock

By Economic Research Service, USDA

Prepared by Walter Ferguson

Trichlorfon has minimal use in agriculture due primarily to resistance problems and currently available alternatives that are generally more effective and provide a broader spectrum of control. For these reasons, surveyed cooperative Extension entomologists suggest that most of trichlorfon's current registered uses may not be continued. The primary advantages of trichlorfon are its minimal adverse effects on beneficial insects in the production of alfalfa seed as compared with alternative chemical control, and its quick-action control of grubs in turfgrass seed and turfgrass is limited to specific geographic areas of production. The limited available data precluded the statistical evaluation of the benefits of Trichlorfon.

Crops

Alfalfa seed

In two of the ten production states, Washington and Montana, trichlorfon is used in alfalfa seed production as part of integrated pest control programs. Trichlorfon has, relative to alternatives, little adverse effect on the beneficial insects important to pollination and is thus important in these two states for maintaining production. In other States, trichlorfon use has been limited due to target pest resistance.

Table 57. Conclusions concerning need for continuation of trichlorfon, selected crops and livestock, 1990.[1/]

Site	Conclusion
Crops	
Alfalfa seed	Needed in NW states as part of IPM programs to provide control of certain primary and secondary pests; trichlorfon has minimal adverse effects on alfalfa pollinators.
Beets, table	Little or no use was reported for insect control.
Blueberries	No change in cost of production, yield, or quality without trichlorfon.
Corn, field	No change in cost of production, yield, or quality without trichlorfon.
Corn, popcorn	No change in cost of production, yield, or quality without trichlorfon.
Corn, sweet	No change in cost of production, yield, or quality without trichlorfon.
Tomatoes	Minimal use was reported.
Turfgrass	Needed for quick-action late season grub control in five of 50 states surveyed.
Livestock	
Cattle, beef and nonlactating	Use of alternatives would result in no change in cost of control, yield, or quality of livestock products. Trichlorfon, as a spray applied insecticide, is used less than alternatives that are applied using other methods due to relative inconvenience of spray-applied insecticides and the need for costly application equipment.
Horses	Use regulated by FDA.

[1/] See individual sections for information on currently available efficacious alternatives to trichlorfon.

Blueberries

Trichlorfon is used on about 2,000 acres of blueberries in Maine, Florida, and New Jersey to control spanworms and gypsy moths. The trichlorfon-treated acreage represents only 2 percent of the total U.S. 132,500 blueberry acres. In most states, spanworms and gypsy moths are considered by Extension entomologists as insignificant or minor pests in terms of total effect on yield or quality of blueberries. In Maine and New Jersey, however, the lack of trichlorfon could result in estimated sporadic yield losses of 10 - 20 percent due to damage by one or both pests. Although no alternative chemicals are specifically labeled on blueberries for controlling spanworm and gypsy moth, other insecticides labeled on blueberries and utilized in pest management programs are generally effective in reducing any infestations of the two pests.

Beets

No use reported.

Corn

Trichlorfon is used on less than 1 percent of the total 5.4 million acres of field corn with insecticides to control the armyworm/cutworm complex. According to the surveyed Extension entomologists in the seven states in which its use is recommended, a reason that trichlorfon is not used more is that it is not readily available in the market place.

Based on its minimal use and the current availability of good chemical alternatives, corn yield would not be affected by loss of trichlorfon. Minimal use was also indicated on popcorn.

Corn, sweet

Minimal use of trichlorfon is reported as both chemical and nonchemical alternatives are apparently preferred. Nonchemical control includes crop rotation, clean cultivation, and the use of beneficial insects.

Tomatoes

Minimal use of trichlorfon is indicated by only two of the 15 states responding to the assessment team survey.

Turfgrass

Of the 50 states surveyed, trichlorfon is reported as needed in five Northeast states for late-season control of white grub damage to turfgrass in golf courses, municipal grounds, residential lawns, and other commercial, governmental and private properties. Trichlorfon is considered to be among the safer materials available in terms of human health and environmental considerations. Among the alternatives, Toxaphene is the recommended control for established grub infestations in the Northeast due to its fast action, but its use is limited in some areas due to its rapid break down in alkaline soils.

Livestock

Cattle, beef and non-lactating dairy

In addition to trichlorfon, alternative insecticides for cattle grub and lice control are applied as injections, pour-ons, food additives, sprays, and dips. The most important alternatives are applied as either injections (Ivomec) or as pour-ons (famphur, fenthion, and Spotton). Trichlorfon and other spray-applied insecticides are used less than injections and pour-on insecticides due to the relative inconvenience of spray-applied treatments and the need for costly application equipment.

Horses

Trichlorfon is used as an oil treatment in horses for bot control. However this use of trichlorfon is regulated by the Food and Drug Administration.

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